FINAL REPORT

to the

U. S. Army Corps of Engineers

Galveston and New Orleans Districts

Telemetric tracking of Kemp's Ridley Sea Turtles (*Lepidochelys kempii*) in Relation to Dredged Channels at Bolivar Roads Pass and Sabine Pass, TX and Calcasieu Pass, LA

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TABLE OF CONTENTS

List of Tables

List of Figures

EXECUTIVE SUMMARY

Hopper dredging by the U.S. Army Corps of Engineers (COE) has been identified as a notable source of mortality to sea turtles in inshore waters (Dickerson and Nelson 1990; Magnuson et al. 1990). Maintenance dredging of intracoastal waterways and about 45 ship channels in the Gulf and Atlantic, disposal of dredged materials, beach nourishment and marine construction (Thompson et al. 1990) all pose risks to sea turtles. Resolution of sea turtle/industry conflicts such as channel dredging, and implementation of proper management of existing stocks are severely compromised by the paucity of quantitative data on species composition, size distribution, spatial and temporal abundance, habitat preference, feeding grounds and nesting activity of sea turtles in nearshore and estuarine waters of the northwestern Gulf.

Texas and Louisiana waters provide essential habitat for Kemp's ridley and green sea turtles. Until recently, virtually no research had been conducted on wild sea turtle populations in Texas. Tracking and mark-recapture studies on green sea turtles in south Texas and numerous sightings by the public at jetties and channel entrances along the central and south Texas coast during the summer suggest these areas serve as developmental habitats for juvenile and subadult sea turtles. Further evidence indicates that jetties and channel entrances along the upper Texas coast and Louisiana coast serve as developmental habitats

for juvenile and subadult Kemp's ridley sea turtles. They associate with jetties, channels and offshore banks.

To learn more about the importance of these habitats, sixteen juvenile turtles (15 Kemp's ridley and 1 loggerhead) equipped with radio and sonic transmitters were released at Sabine Pass, Texas and tracked intermittently during May through mid September 1993. Twenty turtles were fitted with satellite transmitters and released near their capture site at Sabine Pass (l loggerhead and 16 Kemp's ridleys) or Calcasieu Pass, Louisiana (3 Kemp's ridleys).

The abundance of Kemp's ridley sea turtles at Sabine Pass, Texas was much higher than expected. Eighty-six Kemp's ridley turtles were captured between 26 April and 15 September, or 0.9 turtles/kilometer of net/hr. Only two turtles were recaptured a second time. In addition 2 green and 3 loggerhead turtles were captured. Although only four turtles, or 0.3 turtles/km of net/hr, were captured at Calcasieu Pass, Louisiana during May through November, data suggests that mean turtle size at Calcasieu may be larger than that at Sabine Pass (Landry et al. 1994). Only one turtle was captured at Bolivar Roads Pass, Texas.

Mean submergence duration (7.7 min), for all turtles combined, was lower than mean submergence values of 16.7 min and 33.7 min reported by Mendonca and Pritchard (1986) and Renaud (In Press), respectively. Mean percent submergence (93.1%) for all turtles combined was similar to other reported values. In our study, there were no differences in these parameters between turtles < 17kg and those >25kg.

The movement of Kemp's ridley turtles was widespread and measured in tens or hundreds of kilometers, compared to green turtle movement at South Padre Island, measured in meters or kilometers (Renaud 1992 and 1993). Movement of Kemp's ridleys appeared to be dependent on weather conditions and turtle size. Weather seemed to effect both small and large turtles equally, such that turtles would move in the direction of prevailing winds and water currents.

Turtles weighing <17 kg remained near shore, in the vicinity of Sabine or Calcasieu Passes. Their mean distance from shore, 7.9 ± 0.5 km, was significantly lower than the mean distance from shore of turtles >25 kg, 14.9 ± 1.4 km. Linear movements along shore away from release sites were usually less than 50 km for the smaller turtles, while the larger turtles moved from 600 km in 60 days to 1700 km in 217 days . One adult female Kemp's ridley was still being tracked after 227 days (July 10, 1993 to February 17, 1994). This turtle is presently in Charlotte Harbor, Forida near Fort Meyers.

Core area, defined as the region encompassing a minimum of 50% of a turtle's locations during the study, was calculated for each of 15 satellite-tracked turtles. Core areas varied in size from 15.4-22204.7 km^2. Due to limited location information or sustained directional movement, ranges and core areas could not be calculated for any radio-tracked or 4 satellite-tracked turtles.

On five occasions, three of 18 radio-tracked turtles were observed in the Sabine-Neches waterway (SNWW) either between the jetties or off the seaward tip of the jetties. During these occasions, the turtles spent 24% of their time within the confines of the ship channel designated for potential annual hopper dredging. This translates into 1.4-4.2% of these three turtles' daily activities for the entire study. This would represent a minimum amount of time that the turtles spent there. Radio-tracked turtles were not monitored 24 hr/day. It was only by chance that we tracked turtles that happened to use the SNWW. The remainder of the radio tagged turtles may utilize a similar amount of their of time in the channel.

Susceptibility to hopper dredging in the channel may occur during benthic activities of the turtles, such as 1) feeding, 2) crossing the channel as part of their normal movement, or 3) using the channel for passage to enter estuaries in Sabine and Calcasieu Lakes, and other bay systems of the Gulf of Mexico. Dickerson and Nelson (1990) have documented hopper dredging in ship channels as a source of sea turtle mortality. Data are too sparse at this juncture to accurately identify the use of ship channels by the Kemp's ridley sea turtle.

This study increases our knowledge in movements of juvenile Kemp's ridley turtles in the western Gulf of Mexico. Concurrent monitoring of movements of 35 sea turtles is unprecedented. We are now refining our research to allow us to elaborate on the utilization of nearshore nursery habitat for Kemp's ridley sea turtles. Toward this end, the results and conclusions in this report are instructive, but preliminary.

INTRODUCTION

Understanding habitat needs of sea turtles has been recognized as an essential element in successful recovery of their stocks in the Gulf of Mexico (Thompson et al., 1990). Until recently, virtually no research had been conducted on sea turtle populations in Texas, even though Texas inshore waters provide important habitat for both Kemp's ridley (*Lepidochelys kempii*) and green (*Chelonia mydas*) sea turtles.

Historically, green turtles have been common in the lower Laguna Madre of south Texas. A commercial fishery for green turtles in the lower Laguna Madre, Texas, accounted for 22,000 kg of turtles in 1890. By 1900 this resource had been overexploited and the fishery collapsed (Doughty, 1984). Tracking and mark-recapture studies have been conducted on green turtles in south Texas (Manzella, 1990; Renaud et al., 1992; Shaver, 1990). These studies and the sighting of 389 turtles at Brazos-Santiago Pass from April through November (Landry et al., 1993), suggest that jetties and channel entrances along the central and south Texas coast serve as developmental habitats for juvenile and subadult sea turtles. Further evidence indicates that jetties and channel entrances along the upper Texas and lower Louisiana coasts serve as developmental habitats for juvenile and subadult Kemp's ridley sea turtles (Landry et al. 1993 and 1994).

Commercial harvesting of turtles has ceased, but maintenance dredging of 17 ship channels or inlets in the western Gulf could pose potential risk to sea turtles. In particular, hopper dredging by the U.S. Army Corps of Engineers has been identified as a notable source of mortality to sea turtles in inshore waters along the eastern seaboard of Florida, Georgia and South Carolina (Dickerson and Nelson, 1990; Magnuson et al., 1990). Our knowledge of the impacts to sea turtles from channel hopper dredging is severely compromised by the paucity of quantitative data on species composition, size distribution, and spatial and temporal abundance of sea turtles in areas associated with dredging in the northwestern Gulf. Without this knowledge, implementation of proper management is not possible.

We hypothesized that jettied passes and associated dredged channels are human-made habitats selected by young sea turtles. The objectives of this research was to evaluate juvenile sea turtle movements and determine habitat preferences at Sabine and Bolivar Roads Passes in Texas and at Calcasieu Pass in Louisiana. A companion report which adds to the value of this study has been prepared by Texas A&M University, Institute of Marine Life Science, under a separate contract. That report characterizes sea turtle habitat in the area of our study and describes food sources for these turtles.

MATERIALS AND METHODS

Study Area

The study was conducted at Bolivar Roads and Sabine Passes, TX and Calcasieu Pass LA (Fig. 1). Bolivar Roads Pass is the entrance to the Houston Ship Channel. Jetties at this pass are 2.6 km apart at their widest breadth and extend 7.5 km into the Gulf of Mexico. Sabine Pass lies on the Texas-Louisiana border. The jetties, 600 m apart at their widest breadth, extend 5.3 km into the Gulf of Mexico. Calcasieu Pass jetties, located near Cameron, LA are 305 m apart at their widest extent and reach out 1.9 km into the Gulf of Mexico. All of these Passes have small openings in the jetties which allow recreational boat traffic to access adjacent coastal waters without going around the most seaward tip of the jetties.

Capture and Holding of Sea Turtles

Sea turtles were captured by personnel from Texas A&M University's Institute of Marine Life Science, using entanglement nets set at locations along the jetties and from nearshore areas (See Landry 1994).

Immediately following capture, all turtles were transported to holding stations at the U. S. Coast Guard Station in Sabine, TX or the Sabine National Wildlife Refuge in West Hackberry, LA. Turtles were held up to 96 hours in rectangular (0.8 X 0.5 m or 1.5 X 0.6 m) or circular (3.0-m diameter) fiberglass tanks for collection of blood and fecal samples and for photographic documentation. Water depth in tanks was approximately 0.5 m. Straight and curved carapace length (SCL, CCL) and straight and curved carapace width (SCW, CCW) were measured to the nearest 0.1 cm. Each turtle was tagged on the right and left front flippers using inconel tags and with pit tags placed in the right front flipper.

Radio Tracking

Radio transmitters (164.0-165.0 MHz) were fiberglassed to the second neural scute of 18 turtles and sonic transmitters (30-81 KHz) were bolted through the posterior marginal scutes. Turtles were released at their capture sites and monitored intermittently from 22 May through 7 September 1993. Radio transmitters were monitored using a Telonics TR2/TS1 receiver/scanner (mention of trade names or commercial products does not constitute endorsement or recommendation for use) connected to a directional 5-element Yagi antenna. Sonic transmitters were monitored using a Sonotronics directional hydrophone with a receiving range from 2-5 km. Radio monitoring alone occurred from land when weather prohibited tracking by vessel.

With a few exceptions, data were collected daily, between 0600 and 1800 h. Attempts to locate all turtles were made every other day. Up to three turtles were tracked for extended periods during each day. Visual sightings of radio-tracked sea turtles or their positions as determined by sonic telemetry were recorded using a Global Positioning System.

Satellite Tracking

Satellite transmitters (Platform Transmitter Terminal or PTT) were fiberglassed to the second neural scute of twenty turtles. The two largest ridleys were also fitted with radio tags. Turtles were released at their capture sites and monitored until signals were no longer received from the PTTs.

The number and average duration of turtle submergences were computed for day (0800-1959 hrs) and night (2000-0759 hrs) periods by the PTT with the use of a salt water switch located on the tag. These values were used to calculate the total amount of time spent submerged by each turtle. PTTs were programmed to disregard submergences $\leq$ 30 seconds to prevent the accumulation of spurious submergences and submergence durations caused by water splashing on the salt water switch. PTT's did not transmit when under water. In addition to the above information, Service Argos Inc. (SAI)[1] provided the following information for each PTT transmission: 1) PTT identification number, 2) latitude and longitude of PTT, 3) location reliability index, 4) duration of the last submergence, 5) PTT temperature at the time of each PTT transmission, and 6) date and time of PTT transmission. Data were transmitted (401.65 MHz, 50 sec pulse interval) at alternating 6-hr periods for the life of the batteries. Turtles

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[1]Service Argos Inc. 1801 McCormick Drive, Suite 10, Landover, MD 20785, 256 p.

were allowed 24 hours to accustom themselves to carrying a PTT in the natural environment before data were used for analyses.

Study Period Range and Core Areas

An IBM compatible home range program developed by Ackerman et al[2]. was used to develop study period ranges. We ran trials with the data sets comparing the harmonic mean method (Dixon and Chapman 1980) to the minimum convex polygon (Mohr 1947) and various ellipse (Jennrich and Turner 1969, Samuel and Garton 1985) methods. The harmonic mean method appeared to give the best estimate of the area of distribution, even with the small data sets. Therefore, it was used in final range analysis. The range and core area were estimated for each turtle that did not display directional movement and for which sufficient data were collected. Range was defined as the area encompassing the 95% utilization distribution. A core area is a central area which receives consistent or intense use (Kaufmann 1962). Core area size was considered to be the maximum area in which the observed utilization distribution exceeded a uniform distribution. When no core area could be discerned by this method, a potential core area corresponding to the 50% utilization distribution was outlined. For each turtle, only one location per day was retained for analysis, to increase independence between locations. We tested for correlation between range size and both

[2]Ackerman, B. B., F. A. Leban, M. D. Samuel and E. O. Garton. Department of Wildlife, University of Idaho, Moscow, ID 83843.

number of locations and length of tracking period using Kendall's tau (τ).

Environmental Data and Habitat Characterization

Surface water temperature and salinity were recorded using mercury thermometers and temperature-compensated refractometers during radio tracking activity. An estimate of water temperature was also obtained from PTT transmissions. Landry et al. (1994) characterized habitat adjacent to the jetties, at nearshore stations, and at other locations of sea turtles provided by National Marine Fisheries Service personnel. Habitat preferences were determined by monitoring locations of turtles during tracking.

Surface and Submergence Behavior

Surface and submergence duration were calculated for each turtle carrying a radio transmitter. Surface duration was considered the interval between the beginning and ending of radio signals (i.e., when the turtle is within 40 cm of the ocean's surface), and submergence duration the interval between the end of a radio signal and the beginning of the next (i.e., when the turtle is deeper than 40 cm in depth. Overall mean surface and submergence duration and percent of time a turtle spent under water (percent submergence) were calculated for each turtle.

Distributions of surface and submergence times for radio-tracked turtles were tested with the Shapiro-Wilk test for normality (α=0.05). Rejection of the null hypothesis (normal distribution) led to use of the Kruskall-Wallis test for differences in mean submergence or surface times between time periods (α=0.05). Time periods were designated as Dawn (0500-0900), Morning (0900-1300), Afternoon (1300-1700), Dusk (1700-2100), and Night (2100-0100). If a significant difference was indicated, a means test described by Conover (1980) was used to determine which mean differed, again using α=0.05.

RESULTS

Capture and Tagging of Sea Turtles

Sixteen juvenile turtles (15 Kemp's ridleys and one loggerhead) equipped with radio and sonic transmitters were released at Sabine Pass, TX and tracked intermittently during May through mid-September 1993. Their straight carapace lengths and weights ranged from 25.9-59.5 cm and 3.0-30.5 kg. Capture dates and locations, morphometrics, tag numbers and radio/sonic transmitter frequencies of each turtle are given in Table 1. Sixteen Kemp's ridleys and one loggerhead at Sabine Pass and three Kemp's ridleys at Calcasieu Pass were fitted with satellite transmitters and released near their capture sites. Their straight carapace lengths and weights ranged from 34.1-59.5 cm and 5.8-30.5 kg. Their capture dates and locations, morphometrics, tag numbers and transmitter codes are presented in Table 2. Turtles in this report are referenced by the last 4 numbers of their radio frequency preceded by the letter R, for radio, or by their four digit PTT code preceded by the letter S, for satellite.

Sea Turtle Movement Patterns

Sixteen of eighteen turtles, tracked via radio telemetry, moved away from the jetties immediately following release. The remaining two turtles moved parallel to the jetties for 2-3 hr before broadening their range of movements.

Although movement of turtles during a 2-3 hour tracking sessions was usually minimal, < 2 km, turtles did travel 10-15 km from one tracking day to the next. Westerly movement of turtles in May was coincident with weather systems producing strong coastal currents in that direction. R4300 moved 50 km from Sabine Pass to High Island and later returned to Sabine Pass when weather conditions subsided. R5602 travelled 110 km from Sabine Pass to Bolivar Roads Pass. After the weather subsided, R5602 moved 78 km back toward Sabine. At this point, the surface times of this turtle became abnormally long. The turtle was located and removed from the sea with a fungal growth covering its shell. It was treated and rehabilitated by Galveston's National Marine Fisheries Service Laboratory, prior to its release without transmitters later that summer. R5431 moved 133 km from its last position east of Sabine to Pirates Beach, Galveston Island, before returning and entering Bolivar Roads Pass. This turtle also exhibited abnormally long surface times and was picked up for treatment of shell abrasions. It was also released, without transmitters, in the summer. R5300 moved 110 km from Sabine Pass to Bolivar Roads Pass and entered Galveston Bay. Its last position was north of the Texas City Dike near Moses Lake, TX. Movement of all radio-tracked turtles combined extended from 30 km southeast of Sabine Pass, to 133 km southwestward off Galveston Island and inside of Galveston Bay (Fig. 2).

During this study, 33 turtles crossed potential dredging areas at Sabine Pass on 77 occasions. Four turtles spent from 3-15 days in inshore bay systems. On five occasions, three of 18 radio-tracked turtles were observed in the Sabine-Neches waterway, either between the jetties or off the seaward tip of the jetties. During a 12 hour block of tracking, these turtles spent 24% of their time within the confines of the ship channel designated for potential annual hopper dredging. This amounts to 1.4%, 3.4%, and 4.2% of the total movements for turtles R5300, R5601 and R5432 respectively. No turtles were tracked from Bolivar Roads Pass. Movement of individual radio-tracked turtles is presented in figure format in Appendix I.

Movements of four satellite-tracked turtles were monitored beginning in May (2) and June (2). Sixteen more turtles were tagged and released in July (10) and August (6). One tag malfunctioned or fell off on the day of release. The distribution of these tagged turtles extended from Brownsville, TX to Sanibel Island, FL (Fig. 3).

Four turtles larger than 17 kg were apparently caught in transit to some unknown destination. Immediately following their release they left the study site and never returned. S8007, a 22.0 kg loggerhead, moved approximately 180 km from Sabine Pass into Christmas Bay, south of Galveston Island, in 6 days. It spent nearly 10 weeks in Christmas Bay and another two weeks offshore of or behind Galveston Island (Appendix II). S8623, a

30.5 kg ridley, moved eastward. It arrived at the Mississippi Delta in 28 days. By day 44 it had entered the mouth of Mobile Bay. As of February 17, 1994, 227 days following its release, R8623 was located in Charlotte Harbor, FL, 1700 km from Sabine Pass (Appendix II). S8624, a 28.8 kg ridley, moved to the west and south. It entered Copano Bay, TX northeast of Corpus Christi on day 23. By day 25 it was back offshore and moving south. On day 45 it was in the upper Texas Laguna Madre and apparently moved between this area and offshore several times before continuing further down the coastline. The last satellite transmission for S8624, on September 12 (76 days), placed the turtle just north of Port Isabel, TX (Appendix II), 600 km from its Sabine release site. S8004, a 25.5 kg ridley, released at Calcasieu Pass moved 750 km to northeast of the Mississippi Delta after 166 days at sea. (Appendix II).

From May through mid August, all 13 small Kemp's ridleys (<17 kg) remained within 5-10 km of their release site at Sabine Pass. By mid September, 12 of these turtles expanded their range of movements out to 20 km or more. Six turtles moved west along the Texas coast, five moved into Louisiana coastal waters and one moved 50 km offshore. Two of the five turtles that moved into Louisiana waters ended up at Calcasieu Pass. Only one PTT on a small turtle (S7292) was still functioning during fall and winter. Its western movement coincided with the passing of the first cold front over the Texas coast in early November 1993.

S7292 moved approximately 310 km from Sabine Pass to offshore of Matagorda Island, TX. Pass by late November and remained there through early February.

Two turtles, <17 kg, were released at Calcasieu Pass with PTT's. They remained within 5 km of Calcasieu Pass for less than two weeks. S7299 moved toward Marsh Island, LA and was last located near the entrance of Caillou Lake, 130 km east of Calcasieu Pass. Movement of S8008 was extensive, ranging from west of Sabine Pass to 60 km east of Calcasieu Pass. Four turtles released at Sabine moved east to Calcasieu Pass and spent limited time in that area. Two more turtles went southwest and crossed Bolivar Roads Pass. Three turtles released in Calcasieu Pass spent comparatively little time in that area.

Influence of Water Temperature on Sea Turtle Movement

Only one turtle's movement appeared to be influenced by water temperature. S7292 was tracked through summer, fall and winter. With the onset of a cold front in late October, water temperatures off Sabine dropped from 25 °C to 18 °C in a 3 day period. This was the apparent stimulus for the movement of S7292 along the Texas coast to warmer southerly waters. Since then, more cold fronts have dropped Galveston air temperatures near 0 °C. Between October 22, 1993 and February 4, 1994, S7292 remained in water between 12 and 19°C.

Study Period Ranges

Study period ranges were estimated for 15 satellite-tracked turtles which did not exhibit consistent directional movement. Care should be taken in interpreting these results, since the data sets were small for utilization distribution analysis.

These turtles exhibited ranges covering 105.5-59704.6 km^2. Core areas included from 50-69% of the total utilization locations, and were 69.1-22204.7 km^2 in extent (Table 4).

Five turtles displayed bimodal distributions. S7290 had a second distribution area within Sabine Lake. However, the number of locations (3) was very low. S7292 remained near Sabine Pass from 14 August to 1 November. Its second utilization area was off Matagorda Island from mid November through early February. In calculating its utilization distribution, locations during the period of highly directional movement were given a reduced weight to decrease their influence on the overall distribution. The result was a bimodal distribution connected by a travel corridor. S8001 utilized the area immediately around Sabine Pass from 8 July 1993 through 13 August 1993. It then moved about 20 km east. S8002 displayed similar behavior, moving east in mid-August. However, it moved over 40 km to the Calcasieu Pass area. S8009, moved south of Sabine Banks in mid-September and concentrated its activity around 93°30'W 29°20'N.

Kendall's tau test for correlation between range size and number of locations showed positive correlation (τ=0.3714, $p<0.05$). Correlation was even higher between range size and length of tracking period ($\tau=0.6476$, $p<0.005$). The tracking period was considerably longer for S7292 and S8004, and we felt data from these two turtles could have biased correlation analysis. When their data were excluded, there was still significant correlation between range size and length of tracking period ($\tau=0.5513$, $p<0.005$).

Submergence Behavior

Although values for mean submergence and mean percent submergence were lower for radio-tracked turtles than for satellite-tracked turtles (Fig. 4), there was no statistical difference in these parameters between radio and satellite-tracked turtles (T-test, $p>0.05$). However, due to notable differences in methods of data collection, behavior of radio and satellite-tracked turtles will be discussed separately.

Radio-Tracked Turtles. Total percent submergence for individual radio-tracked Kemp's ridley turtles was between 71% and 96%, 92.6% $\pm$ 2.1 for all turtles combined. Submergence durations ranged from 1 sec to 63.5 min. Mean submergence durations varied from 2.7-24.8 min among turtles, 6.4 $\pm$ 1.7 min for all turtles combined. A breakdown of submergence times, by turtle, revealed that 42 to 100% of the submergences were < 10 min and 21 to 79% were < 1 min in duration (Fig. 5). Means tests comparing different time periods showed that, although there were significant differences between mean submergence times, these differences were not consistent among turtles. There were no discernable trends. Comparison of mean submergence times is shown in Table 4.

Satellite-Tracked Turtles. Mean percent submergence for individual satellite-tracked Kemp's ridley turtles was between 91% and 96%, 93.6% $\pm$ 0.8 for all turtles combined. Submergence ranged from 0.6-58.9 min. Mean submergence, by turtle, varied from 5.0-14.0 min. Overall mean submergence was 8.1 $\pm$ 1.3 min.

Turtle weight was not correlated ($r=0.51$ and $p>0.05$) with submergence or percent submergence. The mean submergence and mean percent submergence of two loggerhead turtles in this study fell within the range exhibited by Kemp's ridleys (Fig. 4). No significant differences existed between day and night for mean submergence or mean percent submergence, between species, or between radio and satellite-tracked turtles (T-test, $p>0.05$). No patterns or trends in submergence were definable by time of day (Table 4).

Surface Behavior

Surface intervals for radio-tracked turtles ranged from 1.0 sec to 20.9 min. Mean surface intervals varied from 12.1-83.5 sec between turtles. An analysis of surface interval, by turtle, revealed that 10-45% of surfacings were $\leq$ 5 sec, 21-81% were $\leq$ 15 sec (Fig. 5) and 67-99% were $\leq$60 sec. As with submergence times, tests comparing mean surface times between different time periods showed some significant differences, but no discernable trends (Table 4).

Environmental Data

Water temperatures and salinities near turtle locations ranged from 24-31 °C and 27-40 ppt from mid May through mid September. Maximum standard error on a daily basis for temperature and salinity was 0.8 ° C and 4.5 ppt. Estimations of water temperatures from PTTs, between mid May 1993 and February 1994, were between 10 and 36 °C. Lower temperatures from PTT data were due to the study extending through the winter months. Higher temperatures were possibly due to basking behavior of the turtles. Water temperature and salinity, as well as diversity and abundance of benthic flora and fauna, are discussed in detail in a companion report by Landry et al. (1994).

DISCUSSION

Based on our research and the companion report of Landry et al. (1994), it appears that habitat utilization of the upper Texas and lower Louisiana coasts by Kemp's ridley sea turtles is variable. Small turtles begin to appear near Sabine and Calcasieu Passes in April and May. Turtle size and abundance increases in June, July and August. During September turtle abundance is reduced and seemingly nonexistent by November. Relationships of turtle abundance and food availability are discussed by Landry et al. (1994).

Movement

The movement of Kemp's ridley turtles was widespread and measured in tens or hundreds of kilometers, compared to green turtle movement at South Padre Island, measured in meters or kilometers (Renaud 1992 and 1993). Movement of Kemp's ridleys appeared to be dependent on weather conditions and turtle size. Weather seemed to effect equally, both small and large turtles, such that turtles would move in the direction of prevailing winds and water currents.

Turtles weighing <17 kg remained near shore, in the vicinity of Sabine or Calcasieu Passes. Their mean distance from shore, 7.9 $\pm$ 0.5 km, was significantly lower than the mean distance from shore of turtles >25 kg, 14.9 $\pm$ 1.4 km. Linear movements along shore were usually less than 50 km for the smaller turtles, while the larger turtles moved from 600 to 1700 km from their release sites. One adult female Kemp's ridley was still being tracked after 227 days (February 17, 1994). This turtle is presently in Charlotte Harbor, FL near Fort Meyers.

Satellite-tracked turtles exhibited ranges from 105.5-59704.6 km^2. Noticeably large differences in ranges and core areas for some of the satellite-tracked turtles were probably due to seasonal stimuli which caused them to move away from their release site. Fourteen satellite-tracked turtles had ranges limited to the Sabine-Calcasieu area during June-September. The high correlation between range size and tracking period length of these turtles indicates that the summer seasonal ranges of turtles using the Sabine-Calcasieu area are larger than their tracking period ranges. Although the region of the coast occupied by a turtle varied, nearness to shore ($\leq$ 15 km) of the core area was the rule.

Due to the frequent surfacings by the ridleys in this study, the life of their satellite tags was greatly reduced. Consequently, behavioral characterizations across seasonal boundaries could not be attained for most of these animals.

Submergence Behavior

Data from satellite tags represent actual time that turtles spent under water while data from radio-tracked turtles represent time that turtles were deeper than 40 cm, the length of the radio tag's antenna. This may be one reason for the observed lower submergence durations and percent submergence durations by radio-tracked turtles versus satellite-tracked turtles. Another is that PTT's were programmed to ignore dives <30 sec to prevent spurious dives from being recorded by splashing water.

For these Kemp's ridley and loggerhead turtles, the percent of submerged time per 24-h day ranged from 71-96%. Except for one turtle, this was similar to percent submergence for three juvenile loggerhead (Renaud and Carpenter 1994) turtles (90.0-95.7%), two juvenile Kemp's ridley (Renaud, unpubl.) sea turtles (94.0-98.6%), and 9 green (Renaud et al. 1993) turtles (80.8-97.8%) during the same months. Byles (1989), studying Kemp's ridleys, found that they spent an average 96% of the time submerged. A study of loggerheads in the Canaveral Channel, Florida, revealed that they averaged 96.2% of the time submerged (Kemmerer et al. 1983).

A breakdown of submergence time, by turtle, revealed that 42-100% of submergences were < 10 min and 21-79% were < 1 min. This compares to 74%-99% and 17%-64% of green turtle submergences in data of Renaud et al. (1992) and Renaud et al. (1993). Mean submergence, by turtle, varied from 5.0 - 14.0 min. Overall mean submergence was 8.1 $\pm$ 1.2 min. This was shorter than mean submergence, 18.1 min, of Kemp's ridleys found by Byles (1989), and that of 16.7 min recorded by Mendonca and Pritchard (1986).

Channel Useage

Radio-tracked turtles were not monitored 24 hr/day. Therefore, mere chance allowed us to track turtles in the Sabine

Pass channel. This would represent a minimum amount of time that these turtles spent there. It is reasonable to expect the remaining turtles in the area (telemetered and wild turtles) to behave in a similar manner. In fact, satellite-tracked turtles were also documented in channels and in inshore bodies of water. Bay systems occupied by turtles included Mobile Bay, Mississippi Sound, Sabine Lake, Galveston Bay, West Bay, Christmas, Bay Copano Bay, and the Laguna Madre. Movement into these bay systems would require passage through channels requiring hopper dredging.

The amount of time a turtle spends in the channel is important, as well as the number of turtles in the immediate area and those migrating into the area throughout the year. The chance of a hopper dredge encountering any Kemp's ridley sea turtle is a question yet to be resolved.

Outstanding questions, at this time, include 1) how do movements of turtles change daily and seasonally, 2) do juveniles turtles reoccur between years, 3) how large are turtle populations at Bolivar Roads and Calcasieu Passes compared to Sabine Pass and 4) are turtle movements at Galveston and Calcasieu Passes similar to those at Sabine Pass?

CONCLUSIONS

Kemp's ridley sea turtles occupy coastal and inland nursery areas in the Gulf of Mexico, especially along the upper Texas coast and Louisiana coast. They associate with jetties, channels and offshore banks. Turtle presence in channel areas designated for hopper dredging was documented. However, the degree of channel utilization relative to other coastal habitats has not been clearly determined. Coastal movement related to weather patterns may cloud the issue. Susceptibility to hopper dredging in the channel may occur when turtles 1) feed or rest in the channel, 2) cross the channel as part of their movement along the shoreline, or 3) use the channel for passage to enter estuaries in Sabine and Calcasieu Lakes, and other bay systems of the Gulf of Mexico. Data are too sparse at this juncture to accurately quantify the relative use of ship channels by the Kemp's ridley sea turtle in these areas.

This study increases our knowledge in movements of juvenile Kemp's ridley turtles in the western Gulf of Mexico, through unprecedented simultaneous following of 35 sea turtles. We are further refining our research to allow us to determine the pattern of utilization between nearshore nursery habitat and dredged channels for Kemp's ridley sea turtles. To this end, the results and conclusions of this report are preliminary.

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Table 1. Capture/release dates, locations, measurements and tagging information for one loggerhead and seventeen Kemp's ridley sea turtles tracked by radio and sonic telemetry. Turtles were released at Sabine Pass, TX.

Turtle ID/ Species	Capture Date/ Location	Release Date/ Location	Lengths (cm) Weights (kg)	Flipper/ PIT Tags	Radio/Sonic Freq (with code)
R5300	13-May-93	15-May-93	SL: 33.0 SW: 31.1	QQZ817 (L) QQZ818 (R)	165.300 MHz
L. kempii	29°40.51'N	29°40.44'N	CL: 35.0		40 KHz
	93°50.75'W	93°50.78'W	CW: 36.2 WT: 4.8	1F0A5F1761	No code
R5341	14-May-93	16-May-93	SL: 35.1 SW: 32.3	QQZ839 (L) QQZ840 (R)	165.341 MHz
L. kempii	29°40.48'N	29°40.40'N	CL: 36.5		74 KHz
	93°50.72'W	93°50.60'W	CW: 36.7 WT: 5.4	1F0EG24928	2-4-2-4
R5431	14-May-93	16-May-93	SL: 36.9 SW: 30.2	QQZ837 (L) QQZ838 (R)	165.431 MHz
C. caretta	29°40.46'N	29°40.30'N	CL: 39.7		70 KHz
	93°50.74'W	93°50.10'W	CW: 36.3 WT: 6.1	1F0A5130E6E	3-3-3-3
R4300	19-May-93	20-May-93	SL: 33.6 SW: 30.3	QQZ851 (L) QQZ850 (R)	164.300 MHz
L. kempii	29°39.89'N	29°39.90'N	CL: 35.8		30 KHz
	93°50.13'W	93°50.12'W	CW: 35.0 WT: 4.7	7F7A1A5447	3-3-3-3
R5602	19-May-93	21-May-93	SL: 33.2 SW: 30.3	QQZ845 (L) QQZ846 (R)	165.602 MHz
L. kempii	29°40.41'N	29°40.41'N	CL: 35.3		36 KHz
	93°50.79'W	93°50.83'W	CW: 37.0 WT: 5.0	1F0A59106E	5-2-5-2
R5588	13-Jun-93	18-Jun-93	SL: 36.4 SW: 33.9	QQZ873 (L) QQZ872 (R)	165.588 MHz
L. kempii	29°40.54'N	29°40.20'N	CL: 37.7		36 KHz
	93°50.58'W	93°50.69'W	CW: 39.0 WT: 4.8	1F0E571765	2-2-2-2

Table 1. (cont.) Capture/release dates, locations, measurements and tagging information for one loggerhead and seventeen Kemp's ridley sea turtles tracked by radio and sonic telemetry. Turtles were released at Sabine Pass, TX.

Turtle ID/ Species	Capture Date/ Location	Release Date/ Location	Lengths (cm) Weights (kg)	Flipper/ PIT Tags	Radio/Sonic Freq (with code)
R4623	7-Jul-93	9-Jul-93	SL: 26.7 SW: 24.6	SSA817 (L) SSA818 (R)	164.622 MHz
L. kempii	29°39.90'N	29°40.49'N	CL: 27.4		34 KHz
	93°50.05'W	93°50.55'W	CW: 28.0 WT: 2.7	1F0F372873	4-4-4-4
R4712	7-Jul-93	9-Jul-93	SL: 33.6 SW: 32.2	SSA805 (L) SSA806 (R)	164.711 MHz
L. kempii	29°39.90'N	29°40.29'N	CL: 34.5		166 KHz
	93°50.05'W	93°50.49'W	CW: 36.3 WT: 5.5	1F0F35405D	2-5-2-5
R4930	8-Jul-93	9-Jul-93	SL: 37.3 SW: 35.9	SSA823 (L) SSA824 (R)	164.931 MHz
L. kempii	29°39.90'N	29°40.43'N	CL: 38.9		78 KHz
	93°50.05'W	93°50.47'W	CW: 40.7 WT: 8.0	1F0B7A2933	2-2-2-2
R4513	8-Jul-93	11-Jul-93	SL: 33.5 SW: 33.5	SSA825 (L) SSA826 (R)	164.513 MHz
L. kempii	29°39.90'N	29°40.28'N	CL: 34.5		76.4 KHz
	93°50.05'W	93°50.33'W	CW: 37.6 WT: 5.8	1F0A682946	No code
R4021[1]	8-Jul-93	10-Jul-93	SL: 59.1 SW: 57.5	SSA827 (L) SSA828 (R)	164.021 MHz
L. kempii	29°39.90'N	29°40.42'N	CL: 61.5		70.8 KHz
	93°50.05'W	93°50.36'W	CW: 64.2 WT: 30.5	1F0A660D64	No code (dpth)
R4853	9-Jul-93	11-Jul-93	SL: 31.8 SW: 30.8	SSA843 (L) SSA844 (R)	164.852 MHz
L. kempii	29°41.61'N	29°40.77'N	CL: 33.3		77.2 KHz
	93°49.57'W	93°49.74'W	CW: 35.9 WT: 4.9	1F0A4A5B32	No code (dpth)

[1] Also tagged with satellite transmitter #8623.

Table 1. (cont.) Capture/release dates, locations, measurements and tagging information for one loggerhead and seventeen Kemp's ridley sea turtles tracked by radio and sonic telemetry. Turtles were released at Sabine Pass, TX.

Turtle ID/ Species	**Capture Date/ Location**	**Release Date/ Location**	**Lengths (cm) Weights (kg)**	**Flipper/ PIT Tags**	**Radio/Sonic Freq (with code)**
R4372	7-Jul-93	10-Jul-93	SL: 25.9 SW: 24.4	SSA821 (L) SSA822 (R)	164.371 MHz
L. kempii	29°39.90'N	29°40.28'N	CL: 26.9		80.9 KHz
	93°50.05'W	93°50.30'W	CW: 28.1 WT: 2.9	1F0E6B194F	No code (dpth)
R5412[2]	14-Jul-93	16-Jul-93	SL: 59.5 SW: 57.6	SSA861 (L) SSA860 (R)	165.412 MHz
L. kempii	29°40.76'N	29°40.79'N	CL: 62.3		72.8 KHz
	93°49.81'W	93°49.79'W	CW: 69.4 WT: 28.8	1F0B737A69	No code
R5432	12-Aug-93	14-Aug-93	SL: 42.1 SW: 41.1	SSA905 (L) SSA904 (R)	165.432 MHz
L. kempii	29°40.69'N	29°40.60'N	CL: 43.5		69.5 KHz
	93°49.70'W	93°49.73'W	CW: 47.5 WT: 10.9	1F0F092821	No code
R5589	10-Aug-93	13-Aug-93	SL: 32.5 SW: 30.7	SSA925 (L) QQX804 (R)	165.589 MHz
L. kempii	29°40.49'N	29°39.86'N	CL: 33.7		74.4 KHz
91 HS[3]	93°50.54'W	93°50.07'W	CW: 34.4 WT: 4.9	7F703D9F20	No code
R5602[4]	16-Aug-93	18-Aug-93	SL: 42.5 SW: 40.7	SSA917 (L) SSA916 (R)	165.602 MHz
L. kempii	29°39.89'N	29°39.93'N	CL: 44.3		73.2 KHz
	93°50.05'W	93°50.07'W	CW: 46.0 WT: 10.3	1F1F40087A	No code
R5563	16-Aug-93	18-Aug-93	SL: 41.6 SW: 41.0	SSA919 (L) SSA918 (R)	165.563 MHz
L. *kempii*	29°39.85'N	29°39.85'N	CL: 42.6		80.0 KHz
	93°50.26'W	93°50.11'W	CW: 46.7 WT: 10.5	1F0B772F30	5-5-5-5

[2] Also tagged with satellite transmitter #8624
[3] 1991 Headstart turtle
[4] Radio transmitter #5602 was used on two turtles during different time frames.

Table 2. Capture/release dates, locations, measurements and tagging information for one loggerhead and nineteen Kemp's ridley sea turtles tracked by satellite telemetry. Sixteen Kemp's and one loggerhead were released at Sabine Pass, TX and three Kemp's were released at Calcasieu Pass, LA.

Turtle ID/ Species	**Capture Date/ Location**	**Release Date/ Location**	**Lengths (cm) Weights (kg)**	**Flipper/ PIT Tags**	**Satellite Tag**
S7290	16-Aug-93	18-Aug-93	SL: 39.0 SW: 35.7	SSA911 (L) SSA910 (R)	7290
L. kempii	29°39.89'N	29°39.85'N	CL: 40.3		
	93°50.06'W	93°50.09'W	CW: 41.1 WT: 7.8	1F0F454C41	
S7291	10-Aug-93	14-Aug-93	SL: 34.1 SW: 30.6	SSA903 (L) QQW422 (R)	7291
L. kempii	29°39.90N'	29°39.89'N	CL: 35.1		
91 HS[1]	93°50.05W'	93°50.17'W	CW: 35.5 WT: 5.8	7F7D27690E	
S7292	10-Aug-93	4-Aug-93	SL: 38.6 SW: 36.7	SSA873 (L) SSA872 (R)	7292
L. kempii	29°39.88'N	29°39.89'N	CL: 35.1		
	93°50.16'W	93°50.17'W	CW: 35.5 WT: 8.1	1F0A456B27	
S7293	14-Aug-93	14-Aug-93	SL: 41.0 SW: 39.5	QQZ815(L) QQZ816(R)	7293
L. kempii	29°39.87'N	29°39.89'N	CL: 42.5		
	93°50.18'W	93°50.17'W	CW: 43.2 WT: 9.4	1F0B79500D	
S7294	14-Aug-93	14-Aug-93	SL: 37.5 SW: 35.2	SSA875(L) SSA874(R)	7294
L. kempii	29°39.89'N	29°39.89'N	CL: 39.3		
	93°50.08'W	93°50.17'W	CW: 40.1 WT: 7.7	1F0B667C74	
S7295	7-Jul-93	9-Jul-93	SL: 42.1 SW: 41.0	SSA835 (L) SSA814 (R)	7295
L. kempii	29°39.90'N	29°40.26'N	CL: 43.8		
	93°50.05'W	93°50.54'W	CW: 45.7 WT: 10.9	1F0B7B0358	

[1] 1991 Headstart turtle

Table 2. (cont.) Capture/release dates, locations, measurements and tagging information for one loggerhead and nineteen Kemp's ridley sea turtles tracked by satellite telemetry. Sixteen Kemp's and one loggerhead were released at Sabine Pass, TX and three Kemp's were released at Calcasieu Pass, LA.

Turtle ID/ Species	**Capture Date/ Location**	**Release Date/ Location**	**Lengths (cm) Weights (kg)**	**Flipper/ PIT Tags**	**Satellite Tag**
S7296	7-Jul-93	8-Jul-93	SL: 35.3 SW: 33.5	SSA815 (L) SSA816 (R)	7296
L. kempii	29°39.90'N	29°39.90'N	CL: 36.3		
	93°50.05'W	93°50.05'W	CW: 37.6 WT: 6.3	1F0A460F02	
S7297	8-Jul-93	9-Jul-93	SL: 37.4 SW: 34.7	SSA831 (L) SSA832 (R)	7297
L. kempii	29°39.90'N	29°40.33'N	CL: 38.9		
	93°50.05'W	93°50.45'W	CW: 39.9 WT: 7.6	1F0A2E5554	
S7298	8-Jul-93	9-Jul-93	SL: 36.0 SW: 33.7	SSA833 (L) SSA834 (R)	7298
L. kempii	29°39.90'N	29°39.89'N	CL: 37.2		
	93°50.05'W	93°50.09'W	CW: 37.7 WT: 6.7	1F0A311412	
S7299	20-Jul-93	24-Jul-93	SL: 36.6 SW: 34.5	QQZ889 (L) QQZ890 (R)	7299
L. kempii	29°45.62'N	29°45.62'N	CL: 39.4		
	93°21.40'W	93°21.40'W	CW: 39.7 WT: 7.9	No PIT tag	
S8000	13-Jun-93	17-Jun-93	SL: 36.0 SW: 33.8	SSA801 (L) SSA802 (R)	8000
L. kempii	29°40.58'N	29°40.58'N	CL: 37.1		
	93°50.43'W	93°50.43'W	CW: 38.5 WT: 5.5	1F0B793B1F	
S8001	7-Jul-93	8-Jul-93	SL: 36.4 SW: 34.5	SSA811 (L) SSA812 (R)	8001
L. kempii	29°39.90'N	29°39.81'N	CL: 37.6		
	93°50.05'W	93°50.26'W	CW: 39.3 WT: 6.8	1F0F37415A	

Table 2. (cont.) Capture/release dates, locations, measurements and tagging information for one loggerhead and nineteen Kemp's ridley sea turtles tracked by satellite telemetry. Sixteen Kemp's and one loggerhead were released at Sabine Pass, TX and three Kemp's were released at Calcasieu Pass, LA.

Turtle ID/ Species	**Capture Date/ Location**	**Release Date/ Location**	**Lengths (cm) Weights (kg)**	**Flipper/ PIT Tags**	**Satellite Tag**
S8002	7-Jul-93	9-Jul-93	SL: 35.3	SSA819 (L)	8002
			SW: 33.7	SSA820 (R)	
L. kempii	29°39.90'N	29°39.90'N	CL: 36.3		
	93°50.05'W	93°50.05'W	CW: 37.4	1F0A5D1169	
			WT: 6.2		
S8003	7-Jul-93	9-Jul-93	SL: 46.8	SSA807 (L)	8003
			SW: 45.1	SSA808 (R)	
L. kempii	29°39.90'N	29°40.27'N	CL: 48.4		
	93°50.05'W	93°50.53'W	CW: 49.7	1F0E771B41	
			WT: 13.0		
S8003[2]	16-Aug-93	18-Aug-93	SL: 48.5	SSA807 (L)	
			SW: 46.8	SSA808 (R)	8625
L. kempii	29°39.90'N	29°39.85'N	CL: NA		
	93°50.05'W	93°50.09'W	CW: NA	1F0E771B41	
			WT: 14.2		
S8004	22-Jun-93	26-Jun-93	SL: 58.7	QQZ885 (L)	8004
			SW: 56.2	QQZ884 (R)	
L. kempii	29°45.58'N	29°45.58'N	CL: 61.4		
	93°21.34'W	93°21.34'W	CW: 62.3	1F0A614036	
			WT: 25.5		
S8007	19-May-93	22-May-93	SL: 53.6	QQZ847 (L)	8007
			SW: 47.4	QQZ848 (R)	
C. caretta	29°39.90'N	29°39.96'N	CL: 57.0		
	93°50.13'W	93°50.12'W	CW: 53.7	1F0E64600F	
			WT: 22.0		
S8008	22-May-93	25-May-93	SL: 39.6	QQZ882 (L)	8008
			SW: 38.5	QQZ883 (R)	
L. kempii	29°45.59'N	29°45.62'N	CL: 41.1		
90 HS[3]	93°21.64'W	93°21.62'W	CW: 42.2	7F7D2D3105	
			WT: 9.2		

[2] Recaptured and retagged with satellite tag #8625
[3] 1990 Headstart turtle

Table 2. (cont.) Capture/release dates, locations, measurements and tagging information for one loggerhead and nineteen Kemp's ridley sea turtles tracked by satellite telemetry. Sixteen Kemp's and one loggerhead were released at Sabine Pass, TX and three Kemp's were released at Calcasieu Pass, LA.

Turtle ID/ Species	**Capture Date/ Location**	**Release Date/ Location**	**Lengths (cm) Weights (kg)**	**Flipper/ PIT Tags**	**Satellite Tag**
S8009	17-Aug-93	19-Aug-93	SL: 40.4 SW: 38.0	SSA977 (L) SSA976 (R)	8009
L. Kempi	29°39.90'N	29°39.93'N	CL: 41.7		
	93°50.05'W	93°50.07'W	CW: 43.1 WT: 8.9	1F0B724E16	
S8623[4]	8-Jul-93	10-Jul-93	SL: 59.1 SW: 57.5	SSA827 (L) SSA828 (R)	8623
L. kempii	29°39.90'N	29°40.42'N	CL: 61.5		
	93°50.05'W	93°50.36'W	CW: 64.2 WT: 30.5	1F0A660D64	
S8624[5]	14-Jul-93	16-Jul-93	SL: 59.5 SW: 57.6	SSA861 (L) SSA860(R)	8624
L. kempii	29°40.76'N	29°40.79'N	CL: 62.3		
	93°49.81'W	93°49.79'W	CW: 69.4 WT: 28.8	1F0B737A69	

[4] Also tagged with radio transmitter #4021 and sonic transmitter 70.8 KHz
[5] Also tagged with radio transmitter #5412 and sonic transmitter 72.8 KHz

Table 3. Range and Core Area sizes (km^2) of satellite-tracked turtles which did not show consistent directional movement.

Turtle	Range	Core Area	Locations	Tracking Period	Number of Days Tracked
S7290	105.5	15.4	10	08/18-09/03/93	17
S7291	235.6	69.1	27	08/14-09/17/93	35
S7292	24657.7	6999.0	79	08/14-02/02/94	173
S7294	889.2	251.6	17	08/14-09/03/93	21
S7295	1164.3	330.9	38	07/09-09/19/93	73
S7296	1097.7	415.0	32	07/08-09/03/93	58
S7297	1262.2	471.2	28	07/09-09/04/93	58
S7298	669.7	180.9	42	07/09-09/07/93	61
S8000	154.6	44.3	19	06/17-07/30/93	44
S8001	337.0	84.1	24	07/08-08/25/93	49
S8002	722.2	203.8	43	07/09-09/12/93	66
S8003	973.8	242.9	21	07/09-10/03/93	87
S8004	59704.6	22204.7	49	06/26-12/07/93	165
S8008	5915.5	3679.0	21	05/25-08/14/93	82
S8009	470.2	212.4	25	08/19-10/05/93	48

Table 4. Mean surface (sec) and submergence (min) times by time period. A=Afternoon, D=Dawn, K=Dusk, M=Morning, N=Night. A line above means indicates no significant difference (α=0.05).

Tag	Cat					
4021	Surface	A61.3	D77.2	M80.2		
	Submerge	A17.75	D25.95	M32.3		
4300	Surface	A24.0	M23.9	K47.0	D40.9	N92.3
	Submerge	M9.6	A9.4	K14.9	D23.5	N20.1
4372	Surface	D81.0	M121.5			
	Submerge	D7.0	M14.7			
4513	Surface	M20.35	K26.4	A31.0	D31.6	
	Submerge	M4.7	K3.6	A5.4	D6.4	
4623	Surface	K34.4	A70.15	M140.2		
	Submerge	K7.1	A7.4	M11.5		
4712	Surface	A21.0	K33.3	M38.85		
	Submerge	K4.0	M4.2	A7.6		
4853	Surface	M21.9	D24.6			
	Submerge	D2.6	M3.1			
4930	Surface	M46.2	K142.2	A123.4		
	Submerge	A2.5	K10.0	M10.4	D25.9	
5300	Surface	M37.6	A42.6	D40.8	K175.0	
	Submerge	A4.9	M10.3	D15.0	K24.7	
5341	Surface	D10.8	A14.9	K16.0	M19.1	N48.4
	Submerge	A3.8	K3.9	D5.0	M5.1	N8.3
5431	Surface	A26.2	K47.8	M75.5		
	Submerge	M1.7	A8.6	K14.4		
5432	Surface	K4.4	M10.6	D12.2	A14.7	
	Submerge	D4.1	K4.6	M4.7	A5.9	
5563	Surface	A12.6	M17.2	D23.7		
	Submerge	A3.3	D4.3	M5.0		
5588	Surface	D35.9	K65.0	A54.5	M55.8	
	Submerge	D9.7	M15.4	A18.2	K35.6	
5589	Surface	A25.5	D53.8	M56.5		
	Submerge	D8.7	A9.4	M10.3		
5601	Surface	M23.7	D38.7	A41.1	K60.0	
	Submerge	M9.8	A18.8	D20.9	K33.8	
5602	Surface	A80.0	M99.4	K137.2	D313.2	
	Submerge	A0.03	D0.2	M12.1	K11.9	

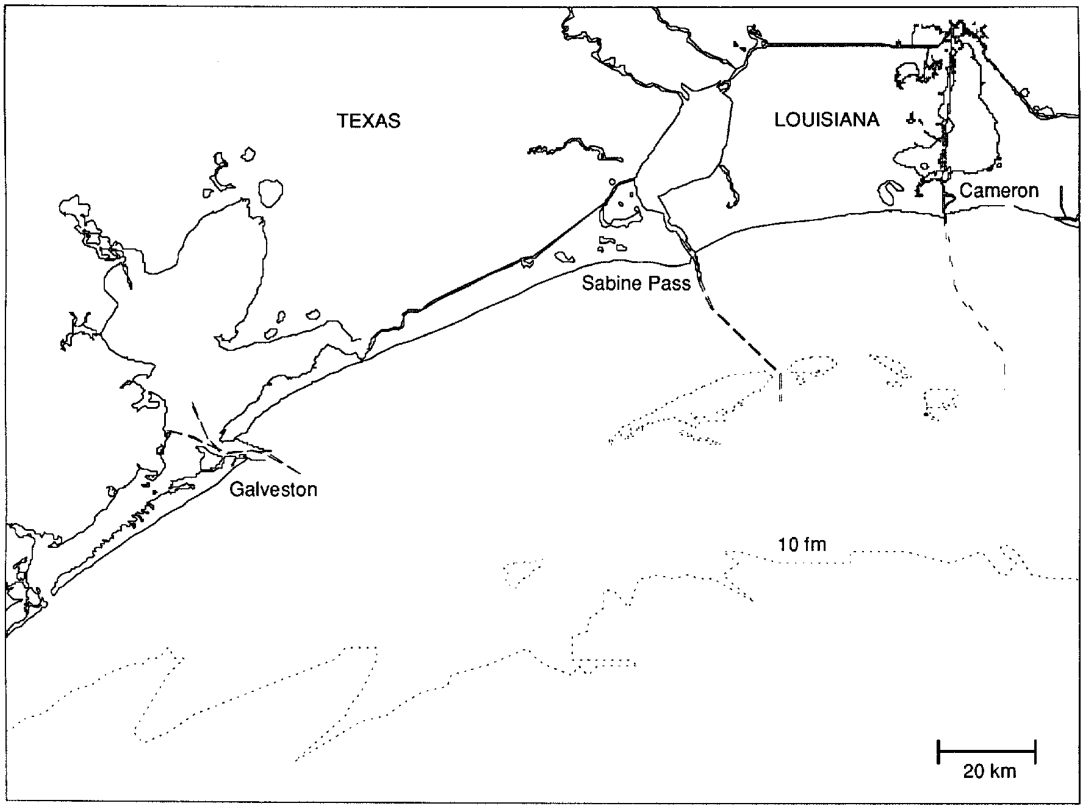


Figure 1. Study area: Sabine Pass, Texas and Calcasieu Pass, Louisiana.

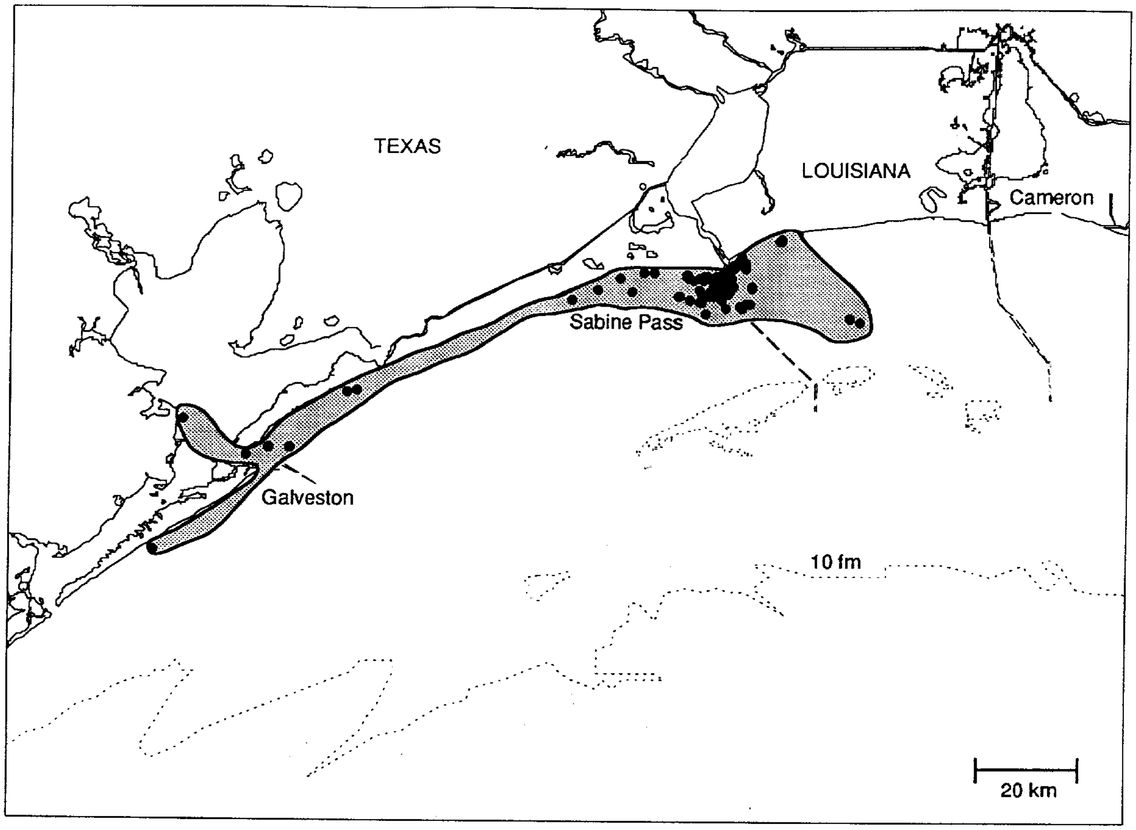


Figure 2. Combined locations of all radio / sonic tracked turtles.

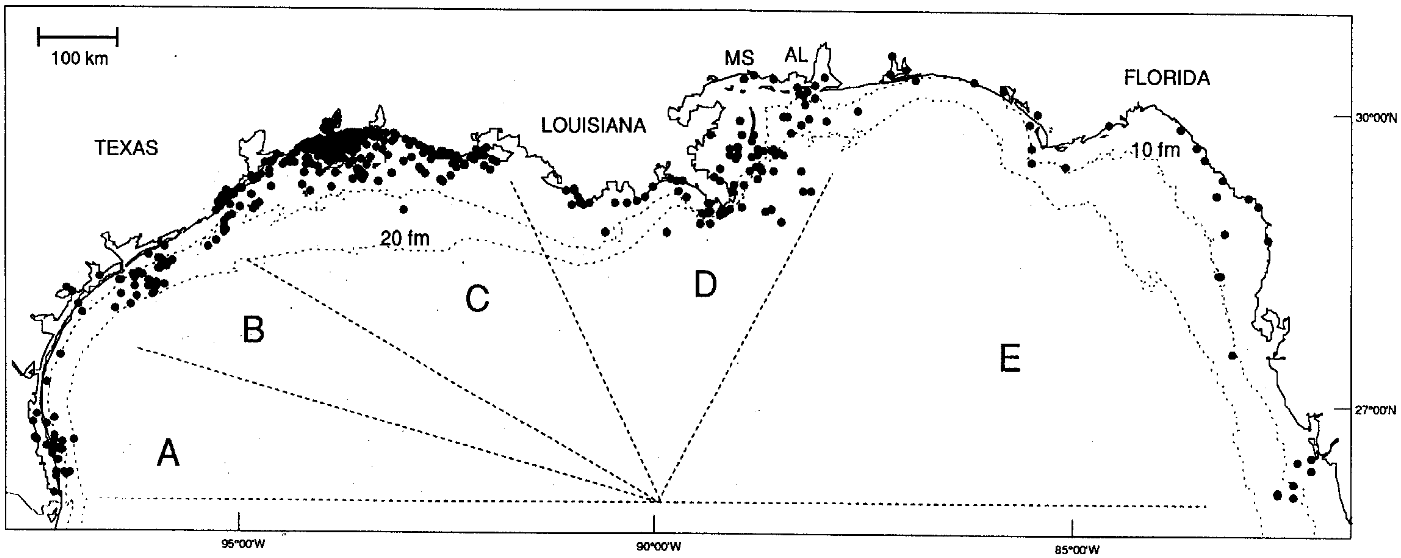


Figure 3. Distribution of satellite tagged sea turtles in the Gulf of Mexico. The number of turtles found in each section is as follows: A).1; B). 2; C). 19; D). 2; and E). 1.

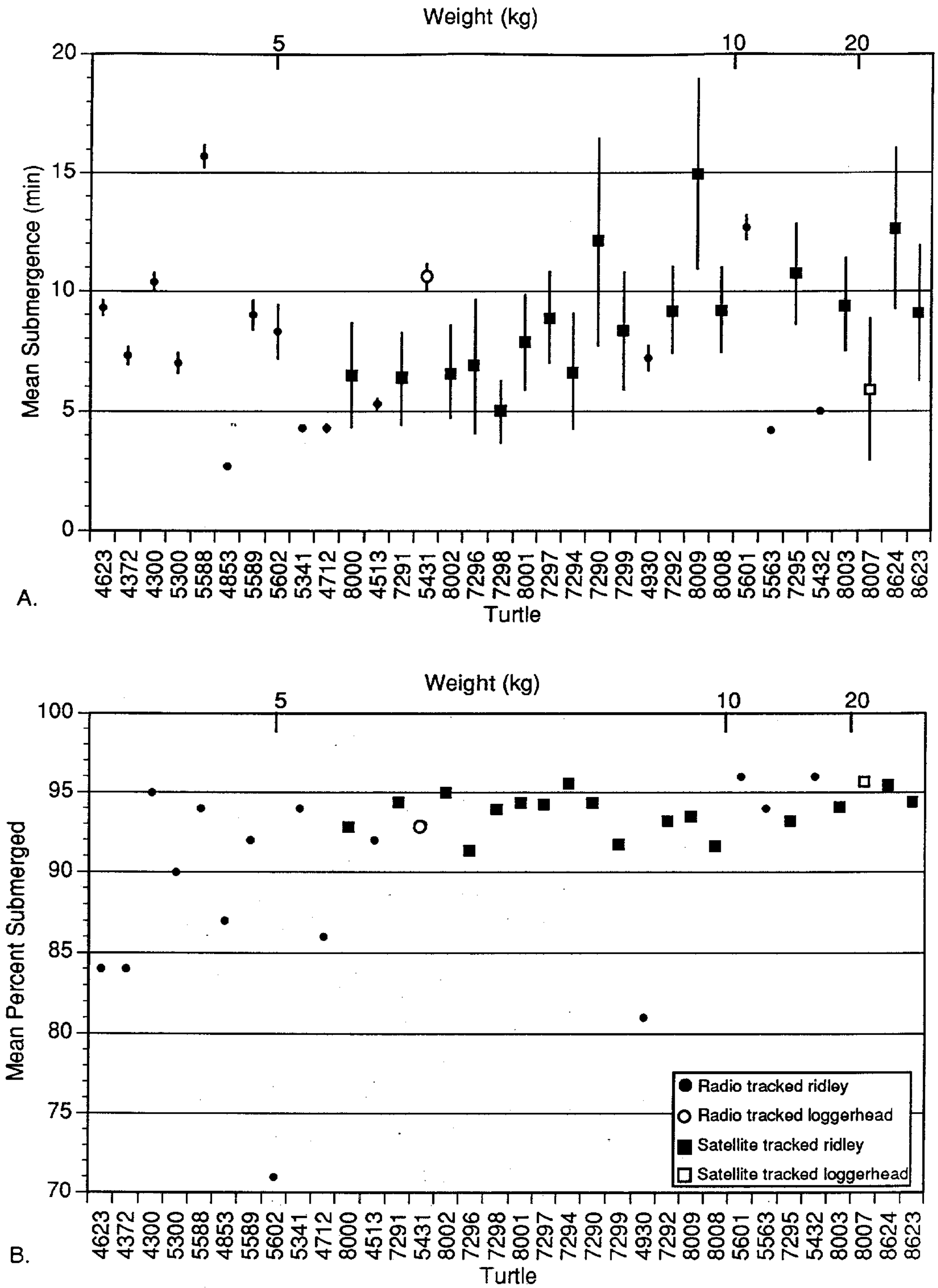
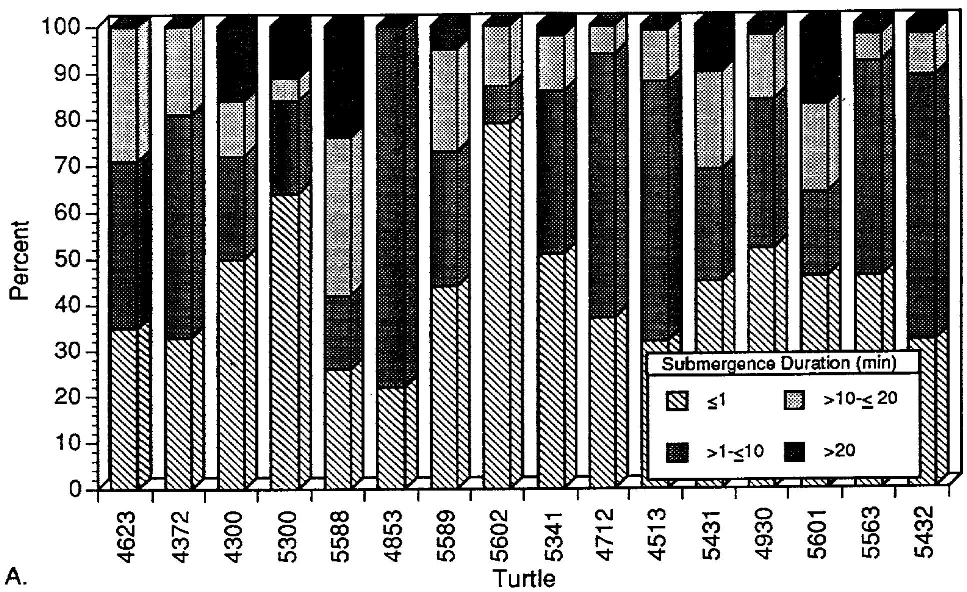
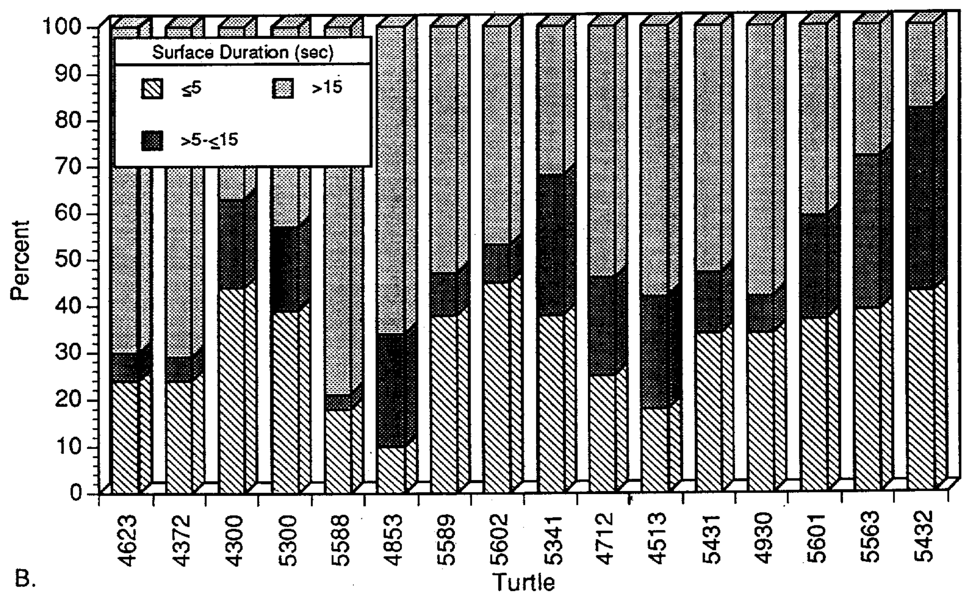


Figure 4. Mean submergence expressed in minutes (± std err), and total percent submergence for each turtle tracked.



A.



B.

Figure 5. Submergence and surface durations by specified time intervals, for each radio tracked turtle.

Appendix I

Locations of Individual Radio-Tracked Sea Turtles

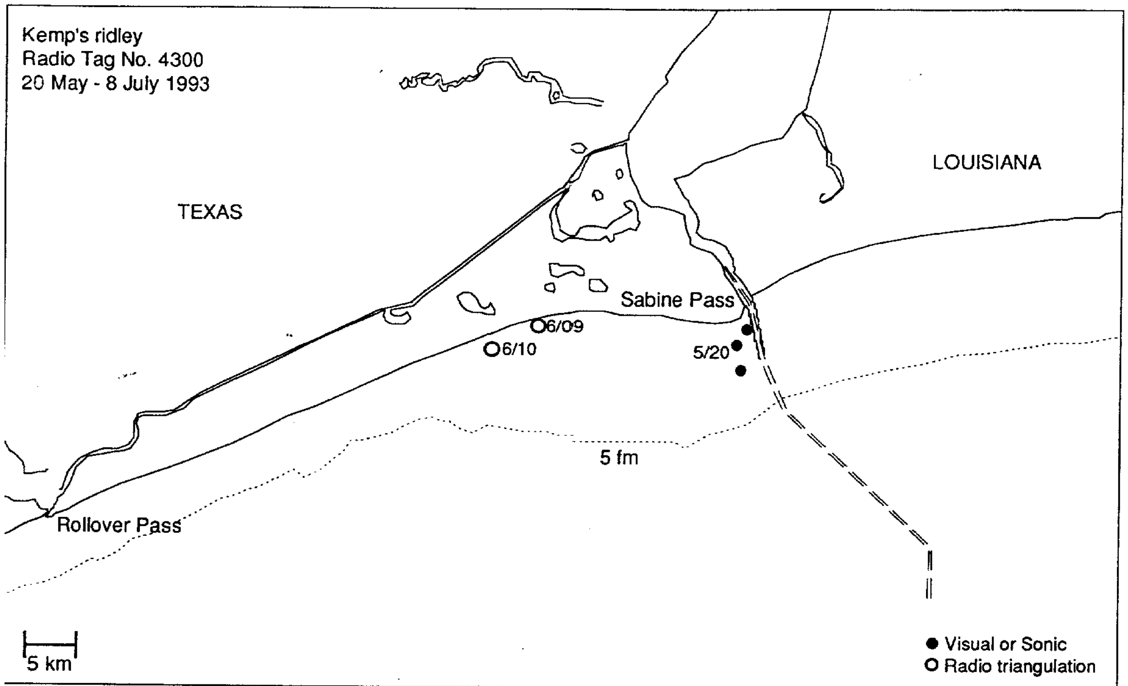


Figure 1. Locations of R4300, based on visual sightings or sonic telemetry.

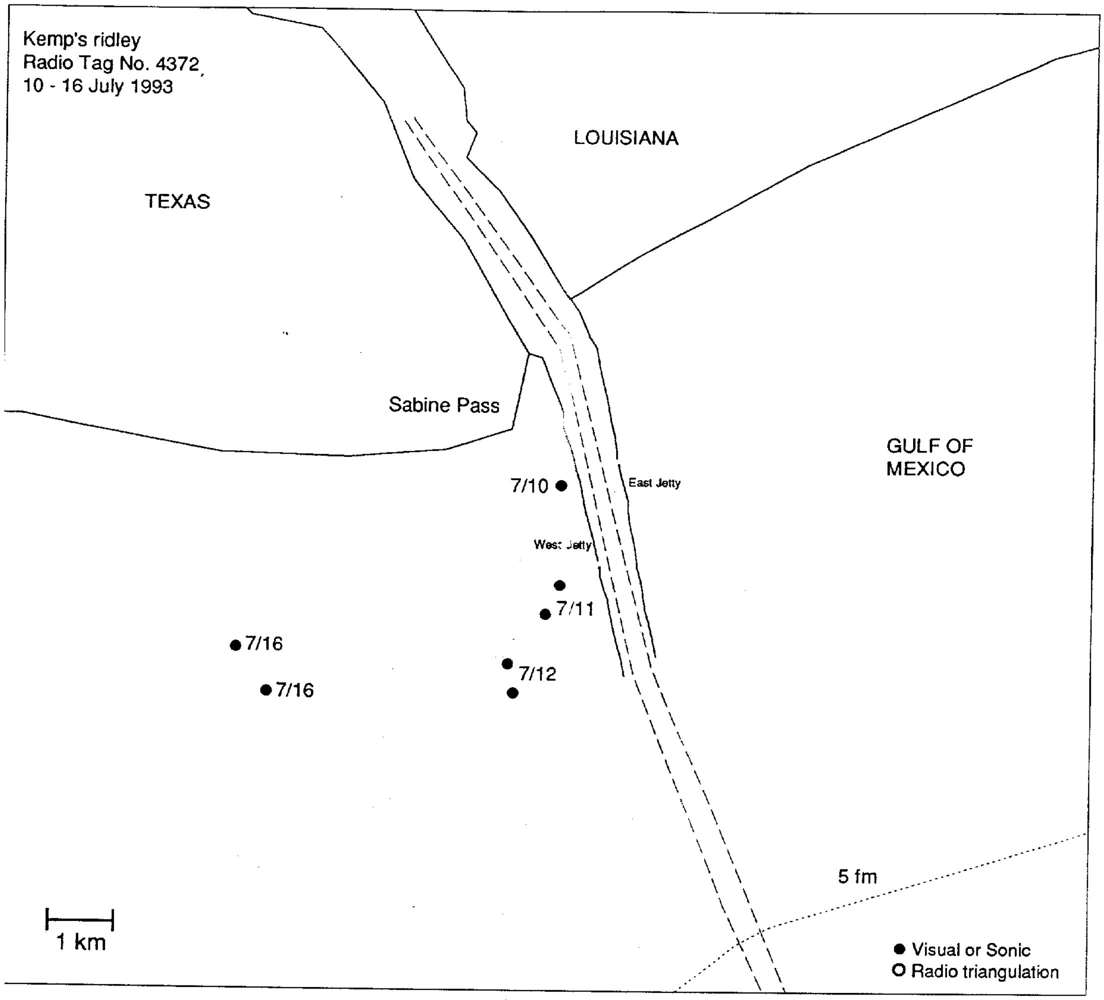


Figure 2. Locations of R4372, based on visual sightings or sonic telemetry.

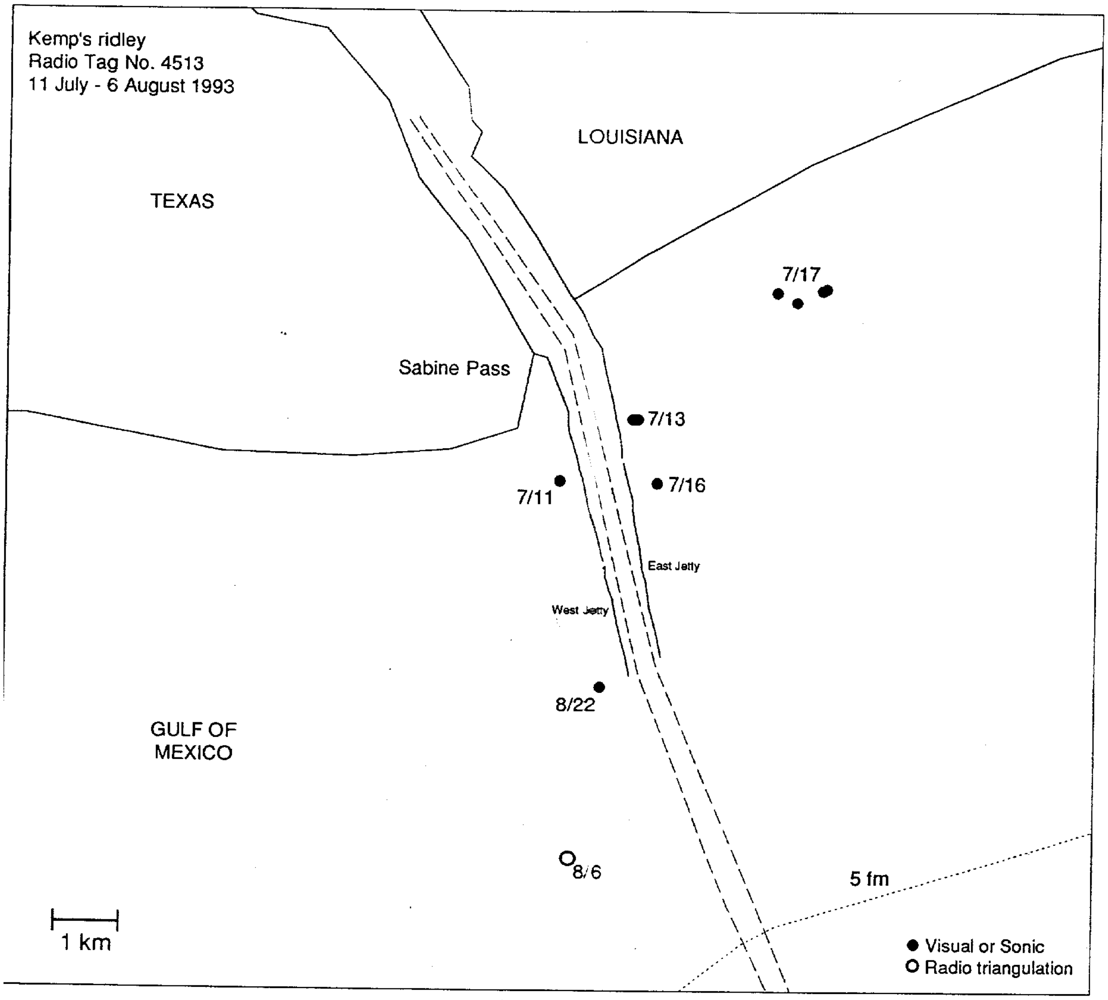


Figure 3. Locations of R4513, based on visual sightings or sonic telemetry.

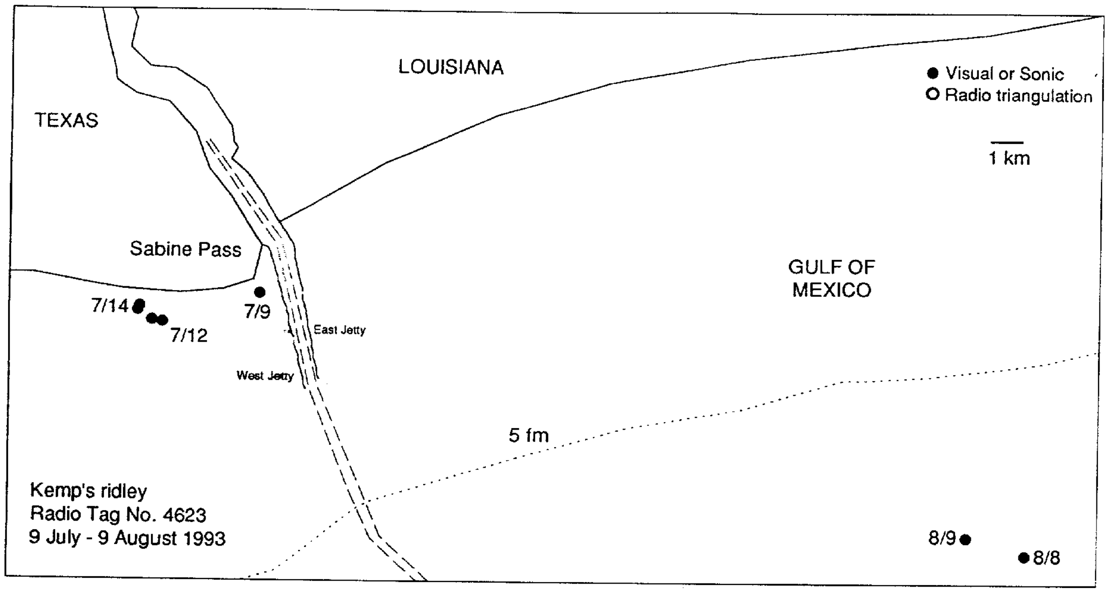


Figure 4. Locations of R4623, based on visual sightings or sonic telemetry.

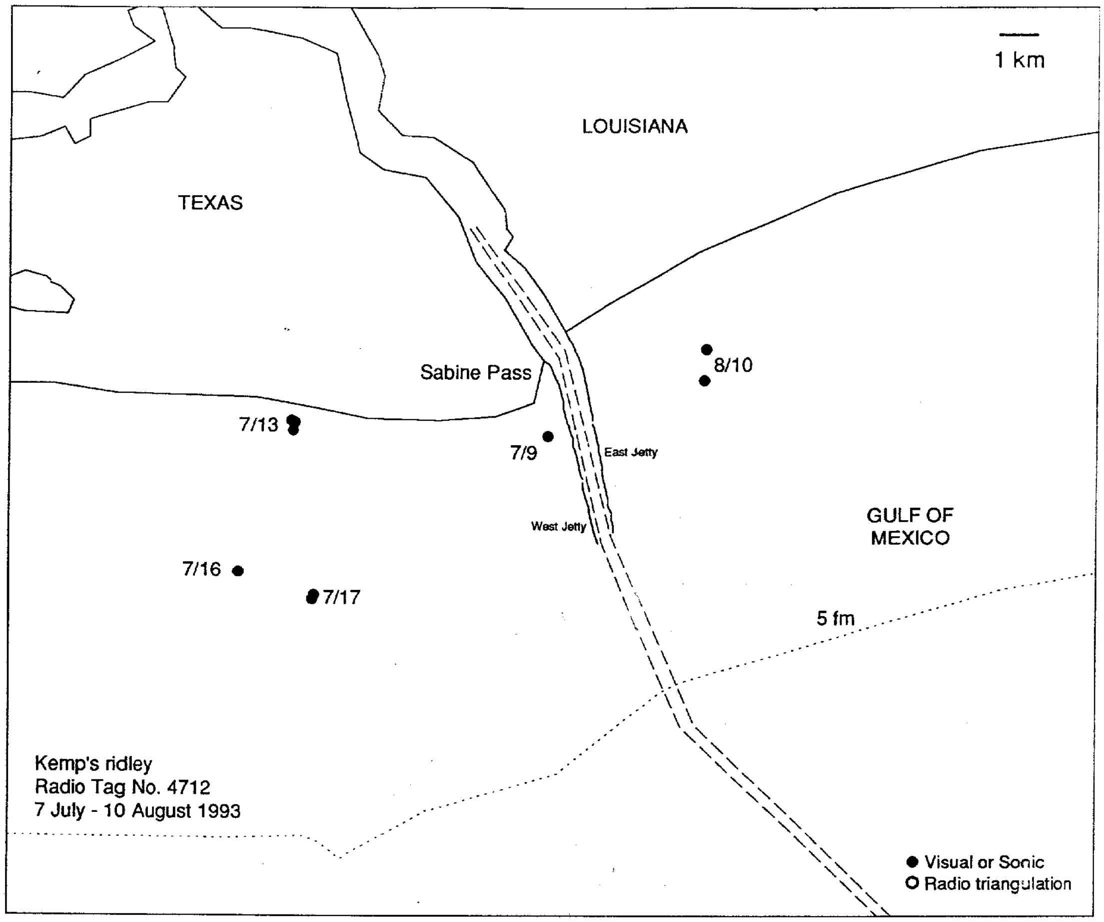


Figure 5. Locations of R4712, based on visual sightings or sonic telemetry.

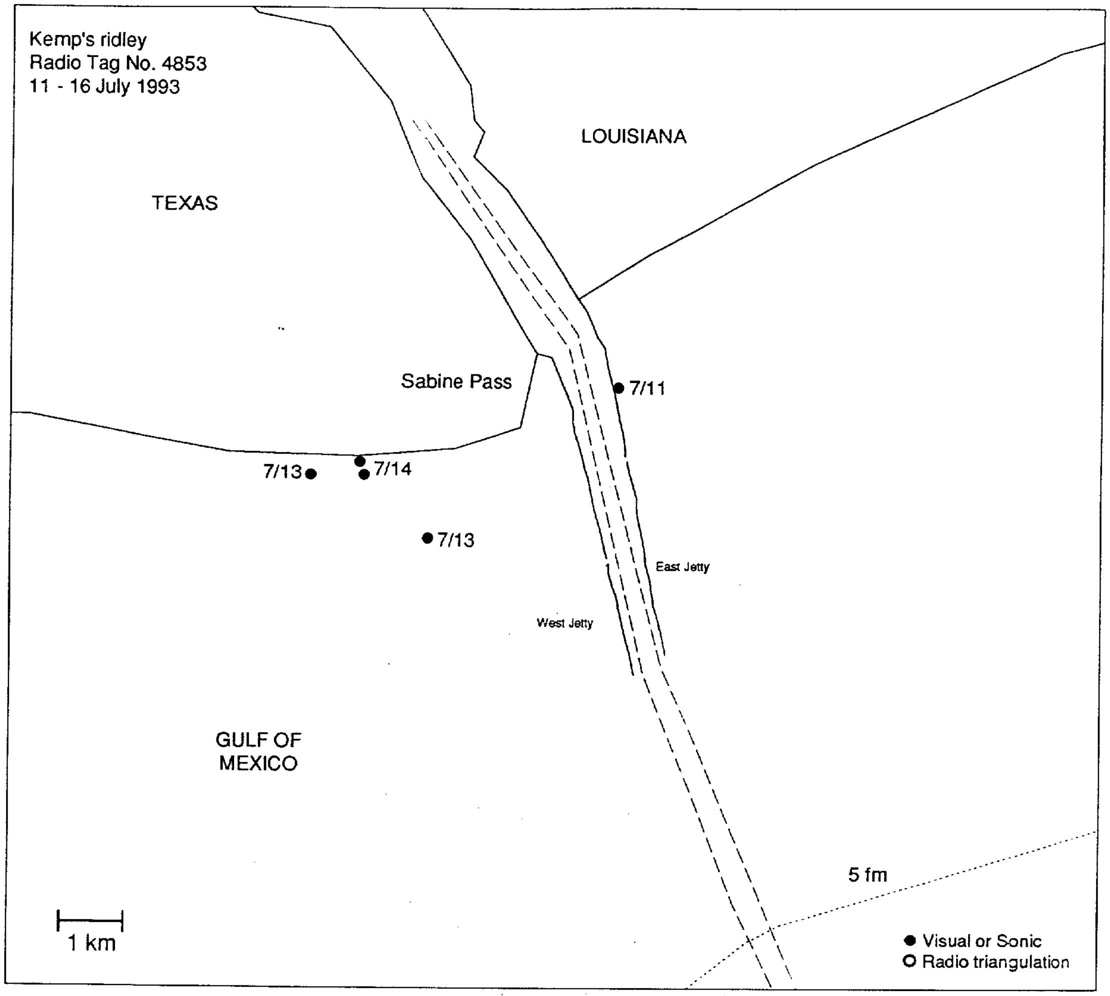


Figure 6. Locations of R4853, based on visual sightings or sonic telemetry.

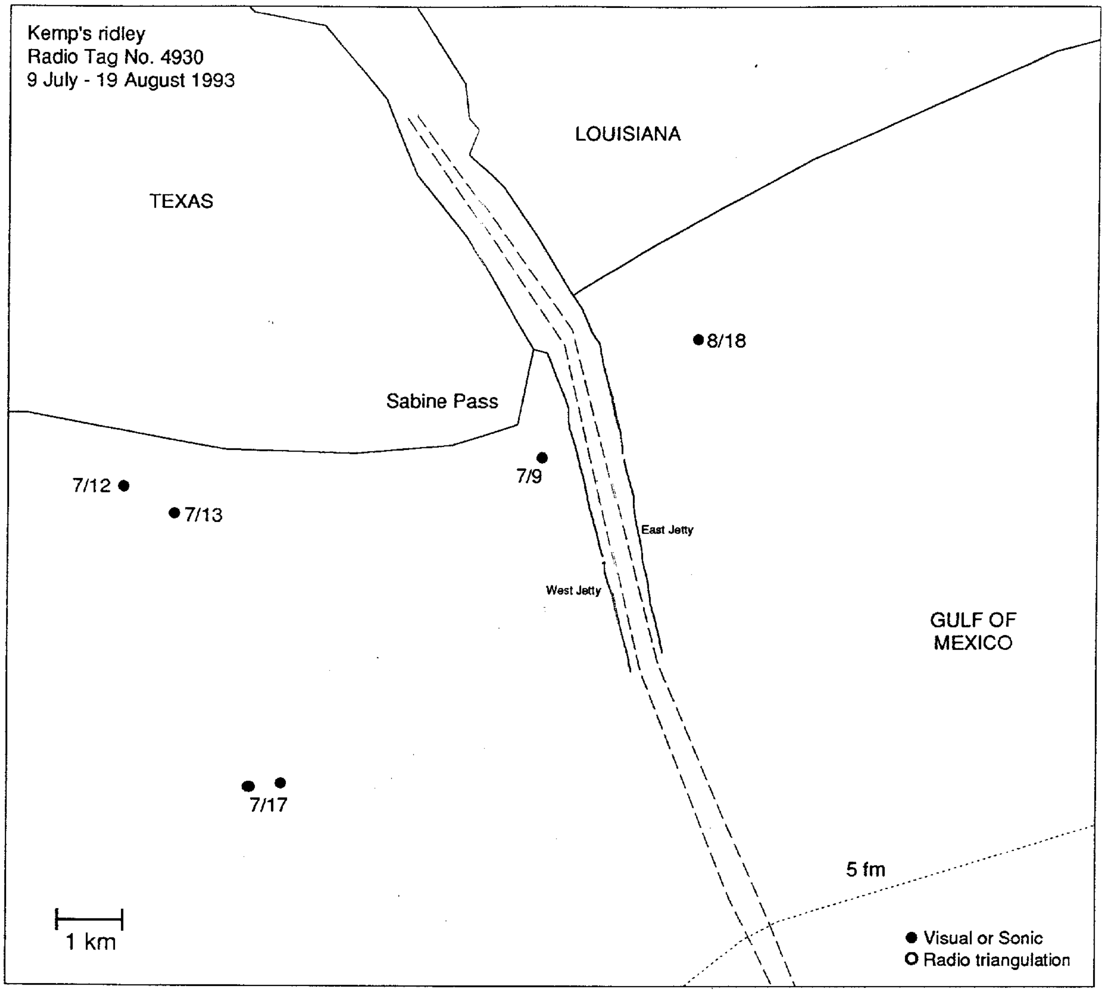


Figure 7. Locations of R4930, based on visual sightings or sonic telemetry.

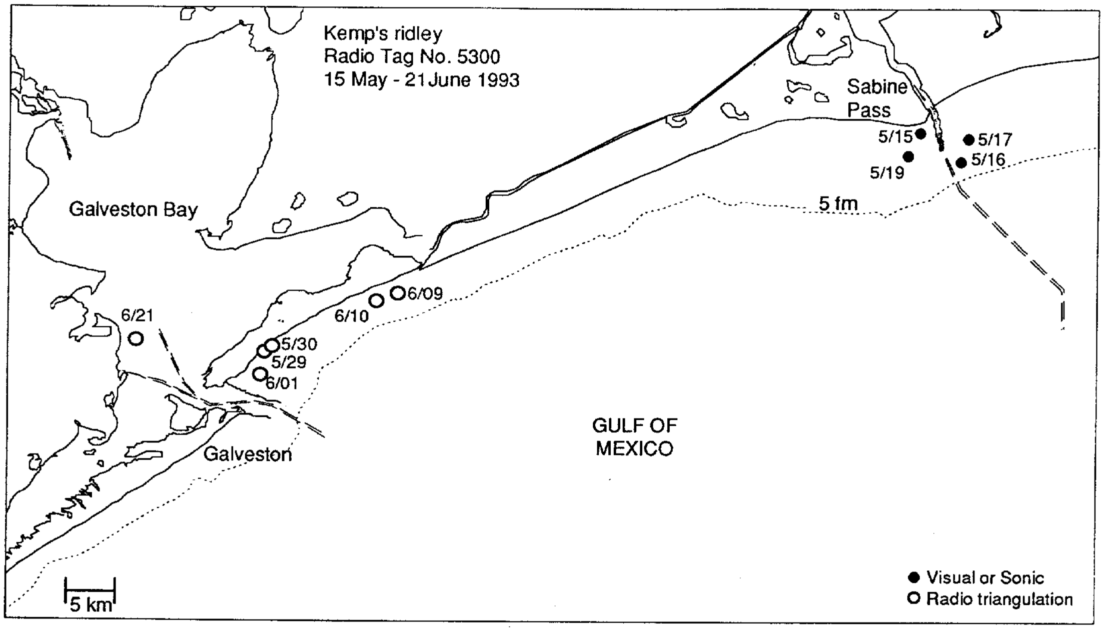


Figure 8. Locations of R5300, based on visual sightings or sonic telemetry.

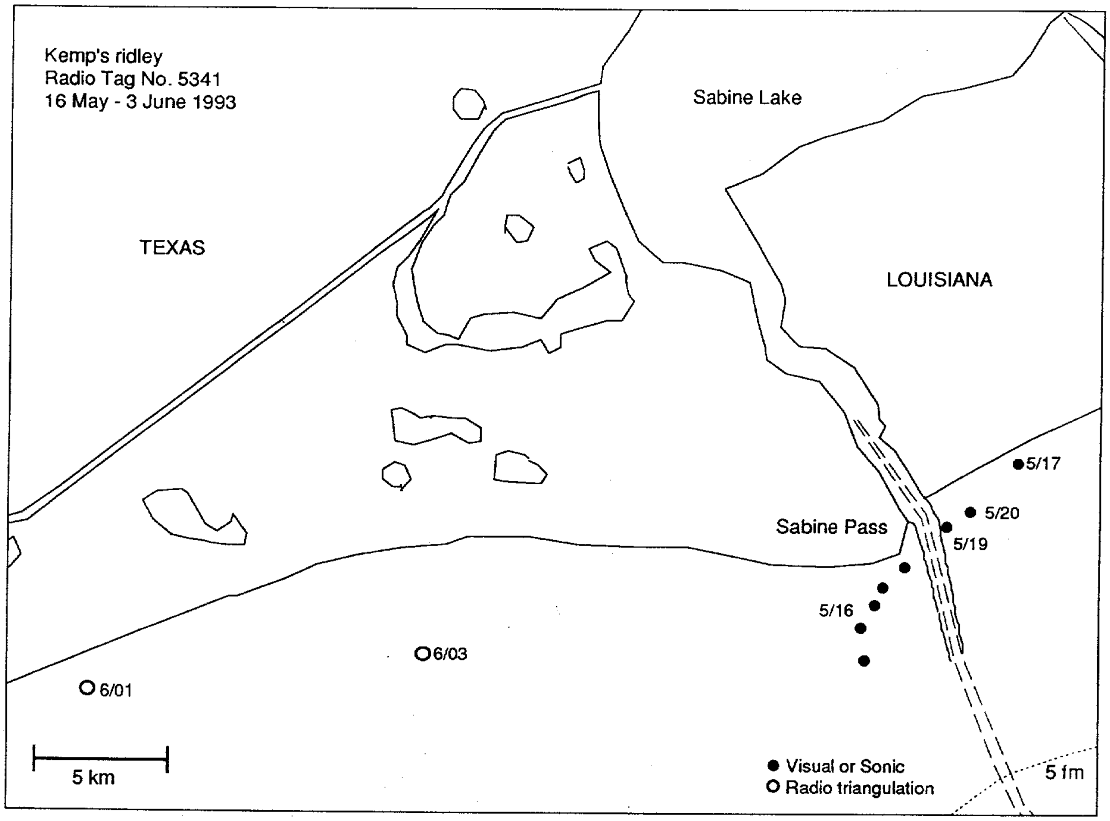


Figure 9. Locations of R5341, based on visual sightings or sonic telemetry.

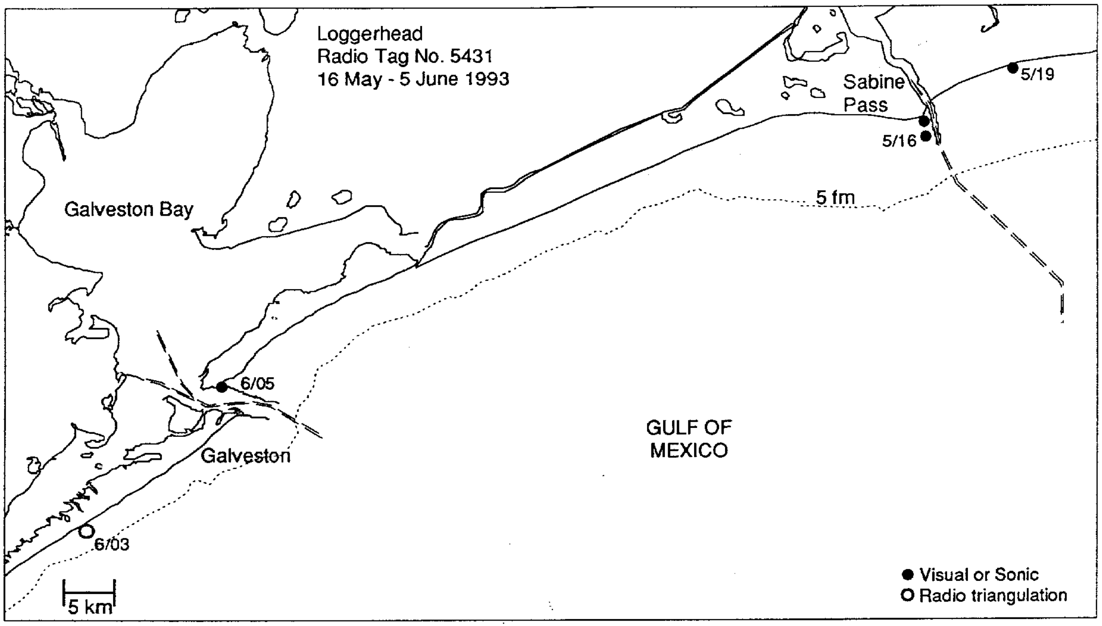


Figure 10. Locations of R5431, based on visual sightings or sonic telemetry.

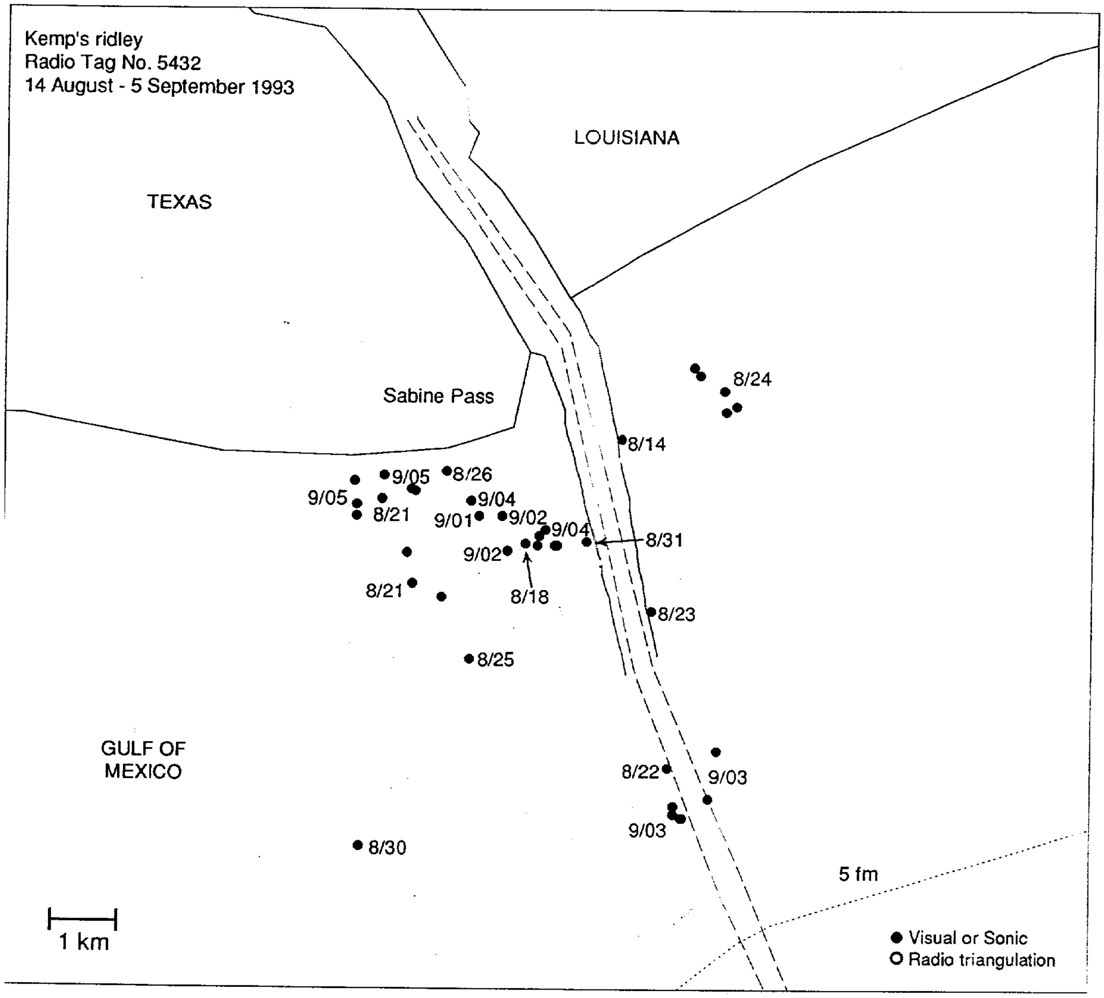


Figure 11. Locations of R5432, based on visual sightings or sonic telemetry.

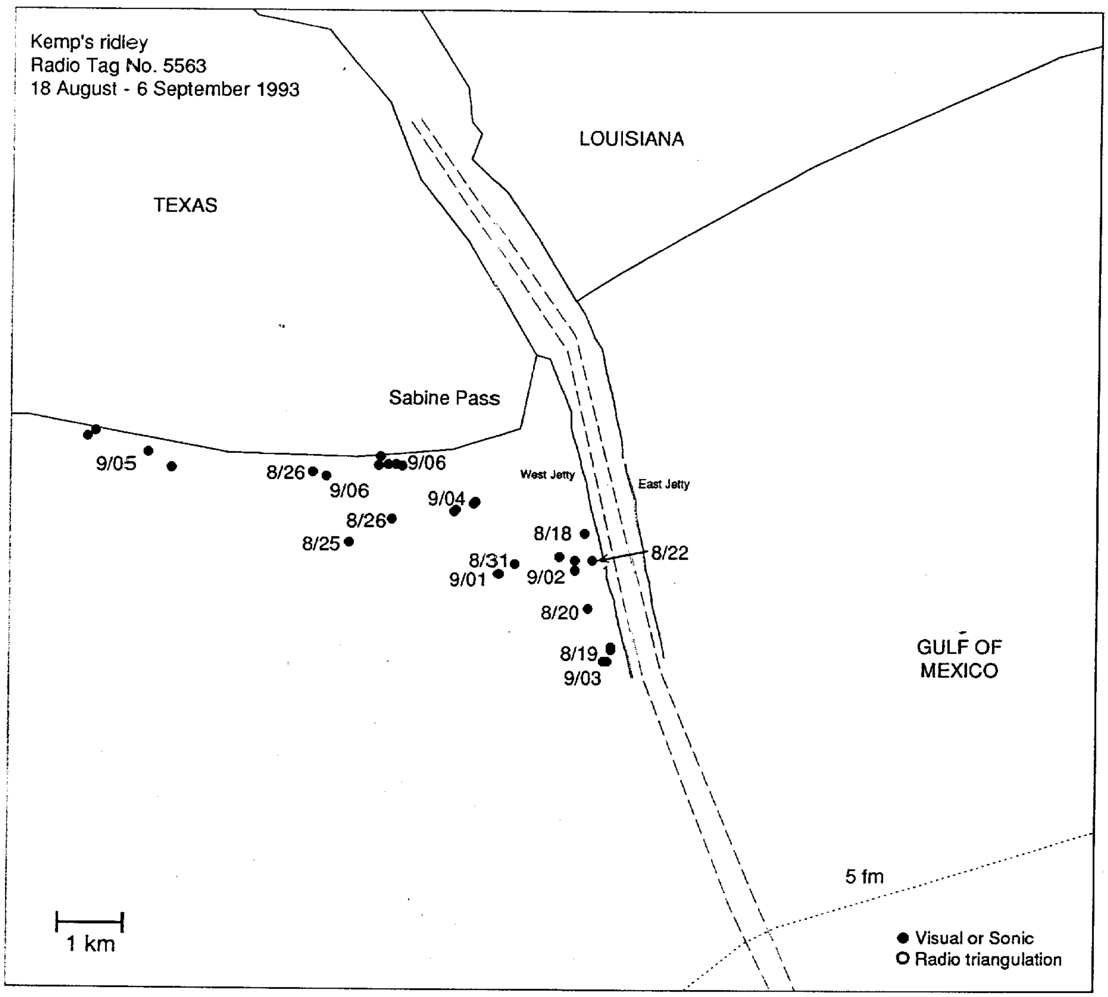


Figure 12. Locations of R5563, based on visual sightings or sonic telemetry.

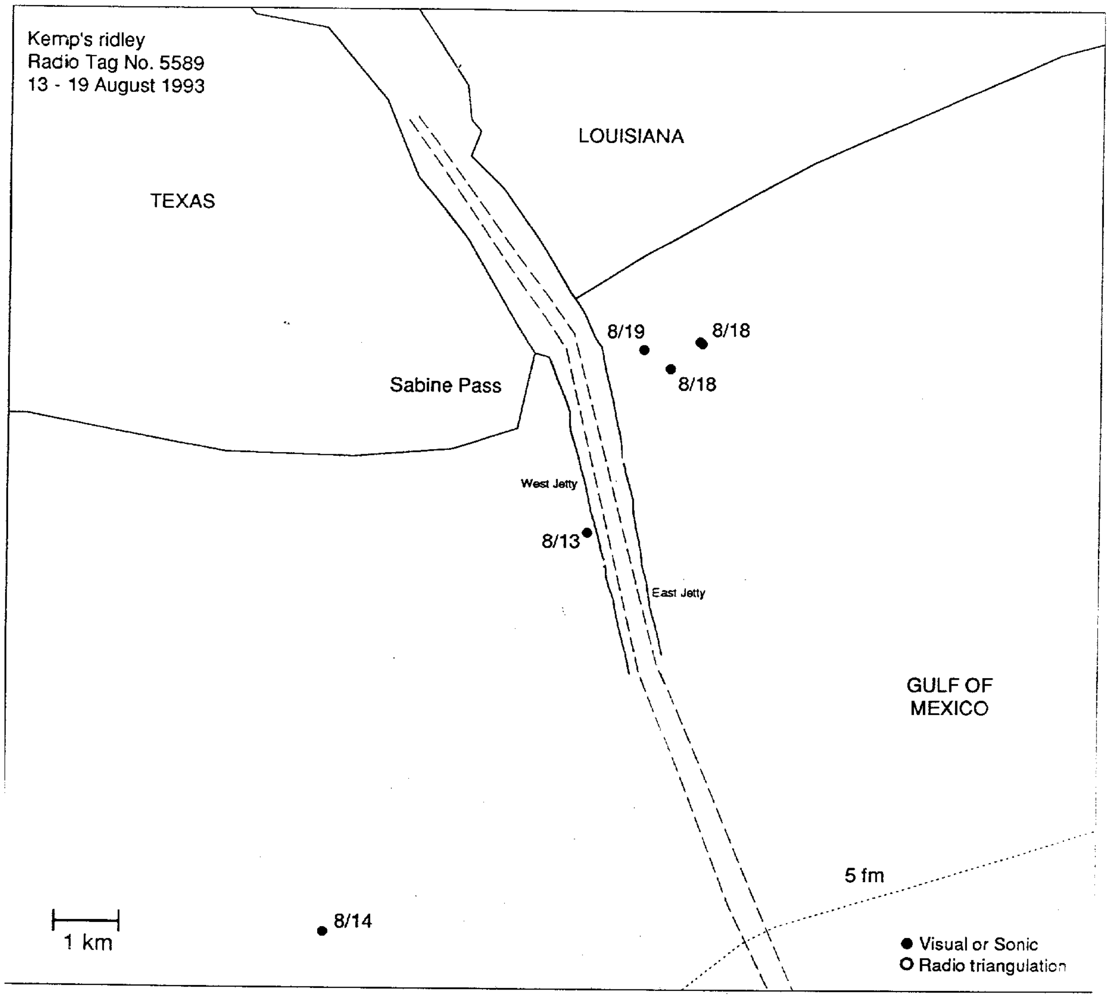


Figure 13. Locations of R5589, based on visual sightings or sonic telemetry.

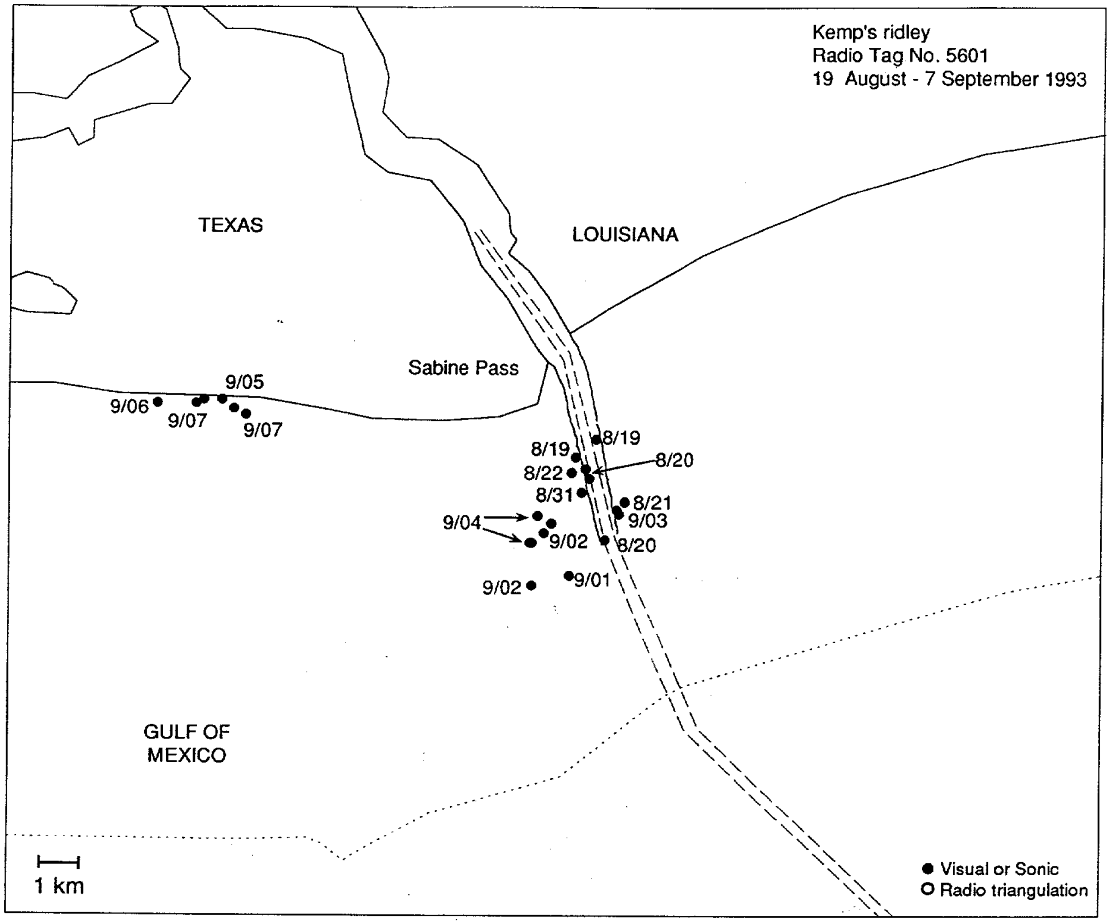


Figure 14. Locations of R5601, based on visual sightings or sonic telemetry.

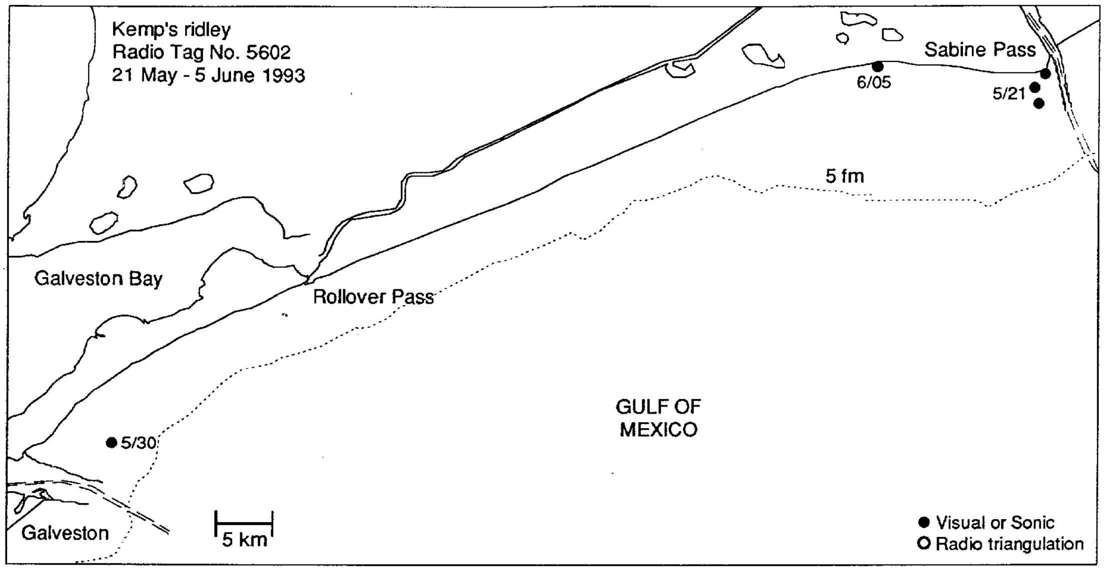


Figure 15. Locations of R5602, based on visual sightings or sonic telemetry.

Appendix II

Locations of Individual Satellite-Tracked Sea Turtles

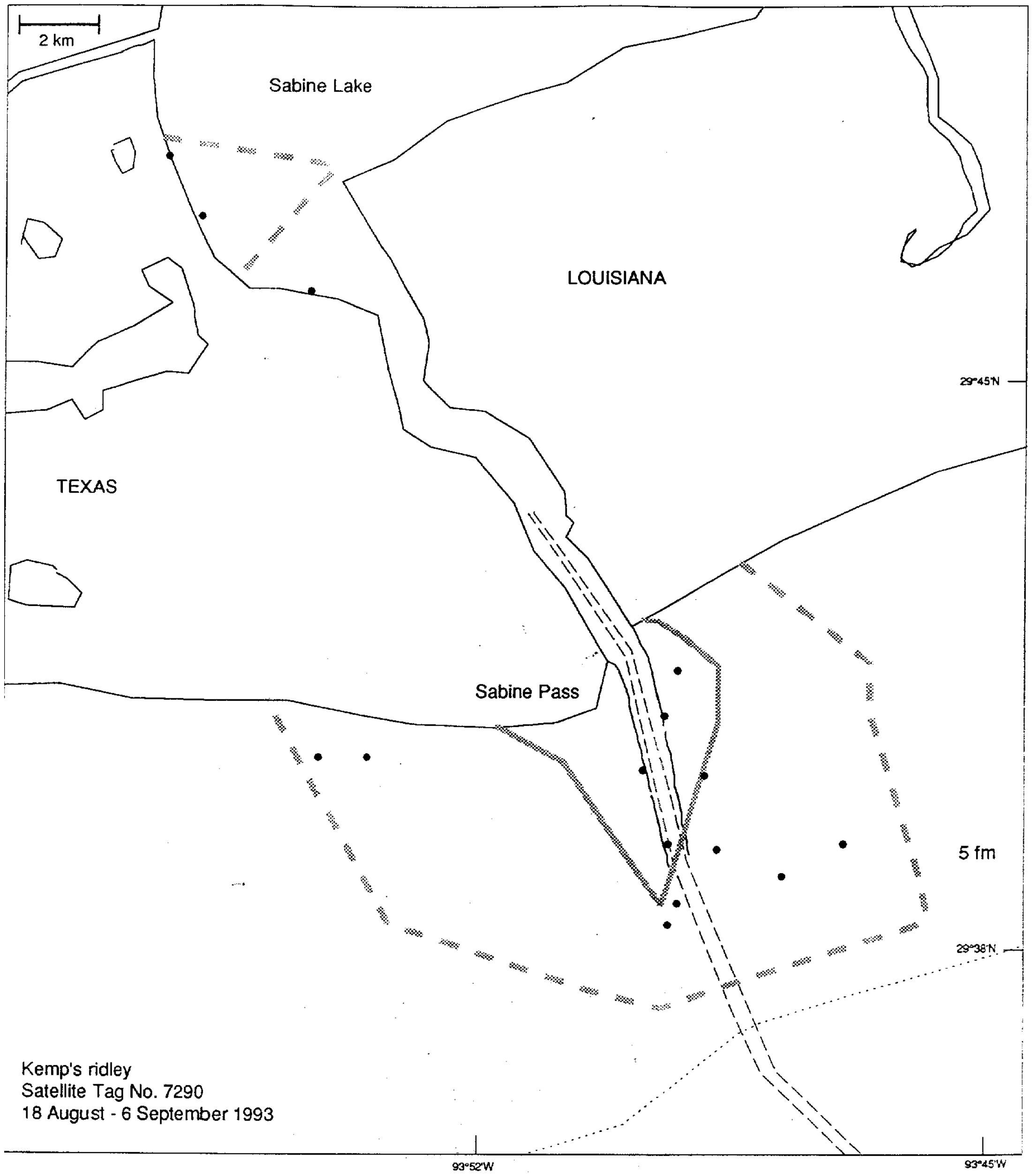


Figure 1. Range (95% utilization distribution) and core area (50% utilization distribution) for S7290. Range is outlined with a dotted line and core area is outlined with a solid line.

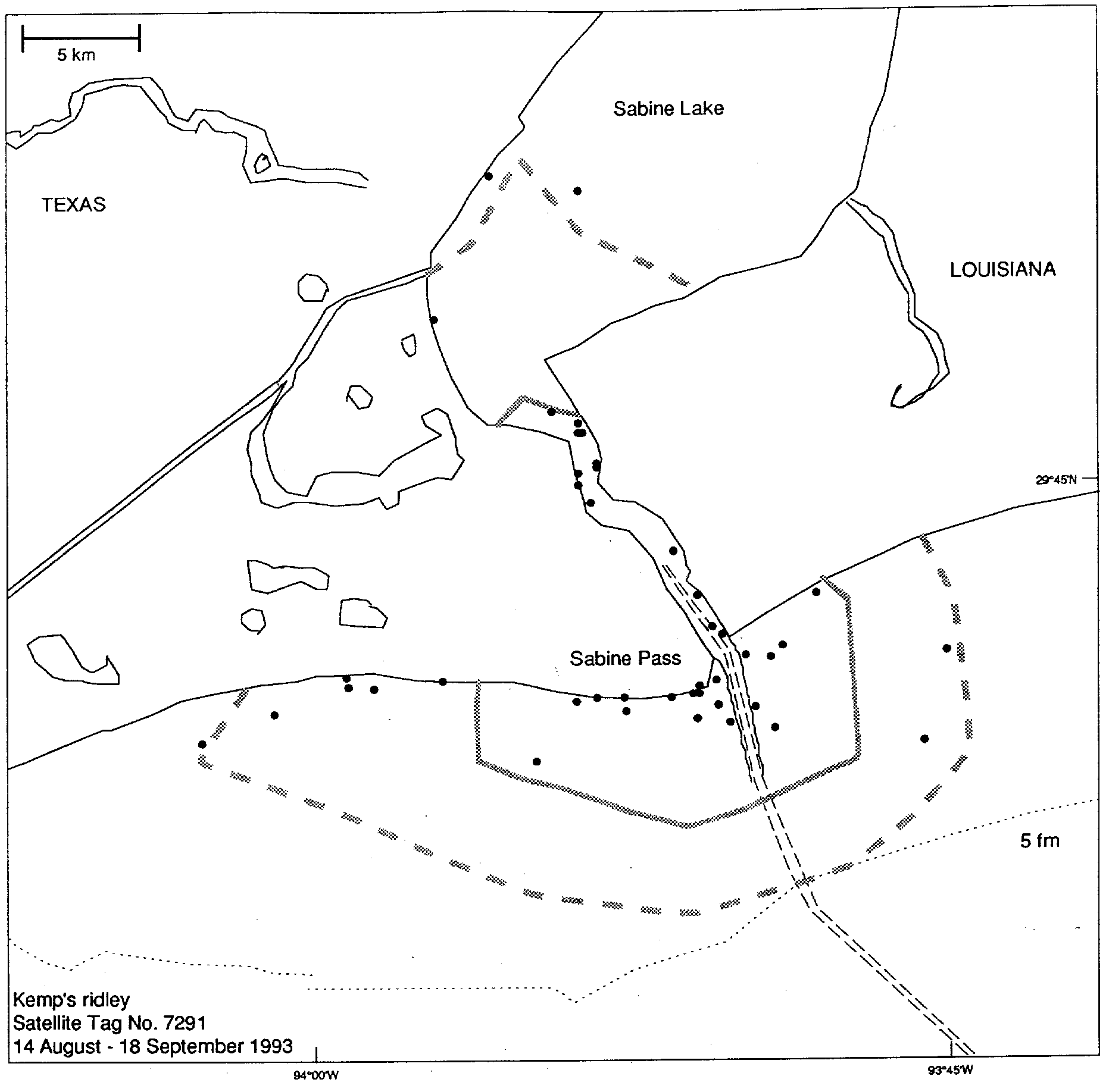


Figure 2. Range (95% utilization distribution) and core area (69% utilization distribution) for S7291. Range is outlined with a dotted line and core area is outlined with a solid line.

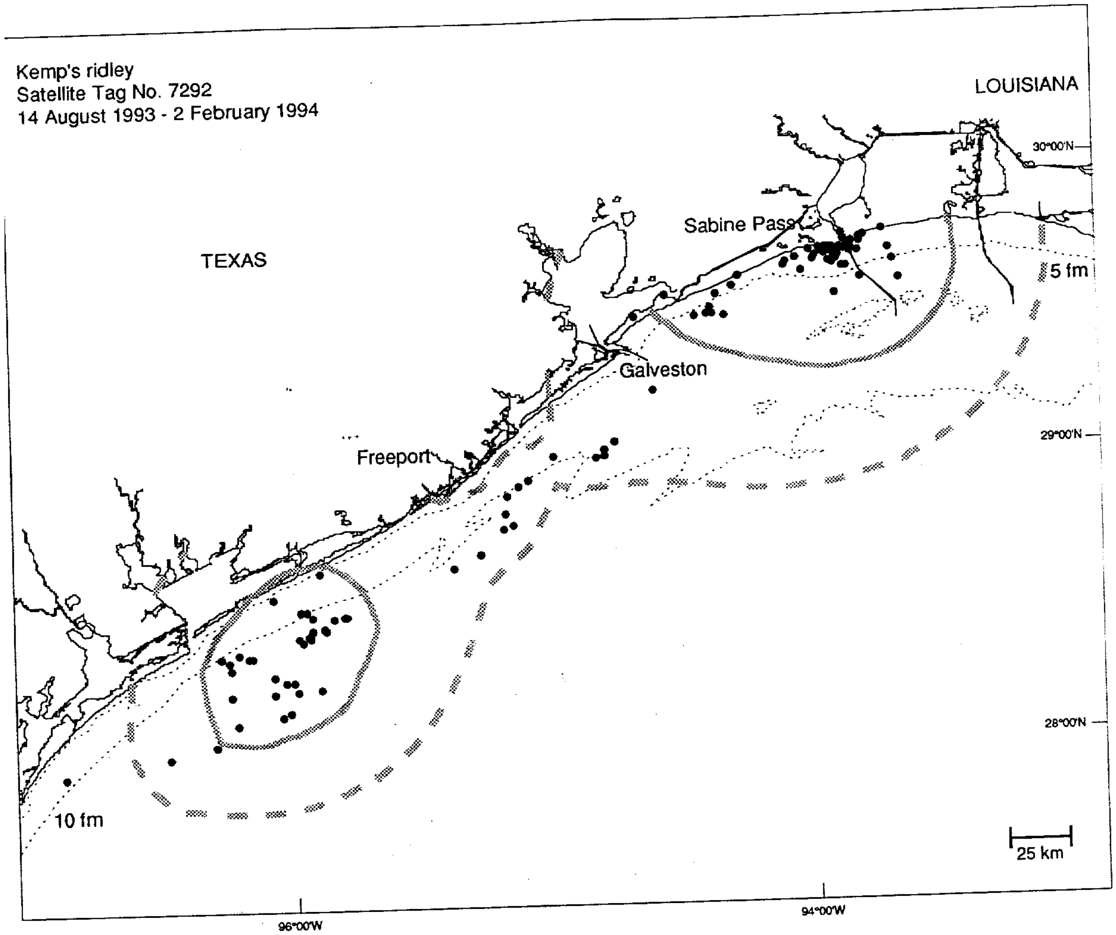


Figure 3. Range (95% utilization distribution) and core area (62% utilization distribution) for S7292. Range is outlined with a dotted line and core area is outlined with a solid line.

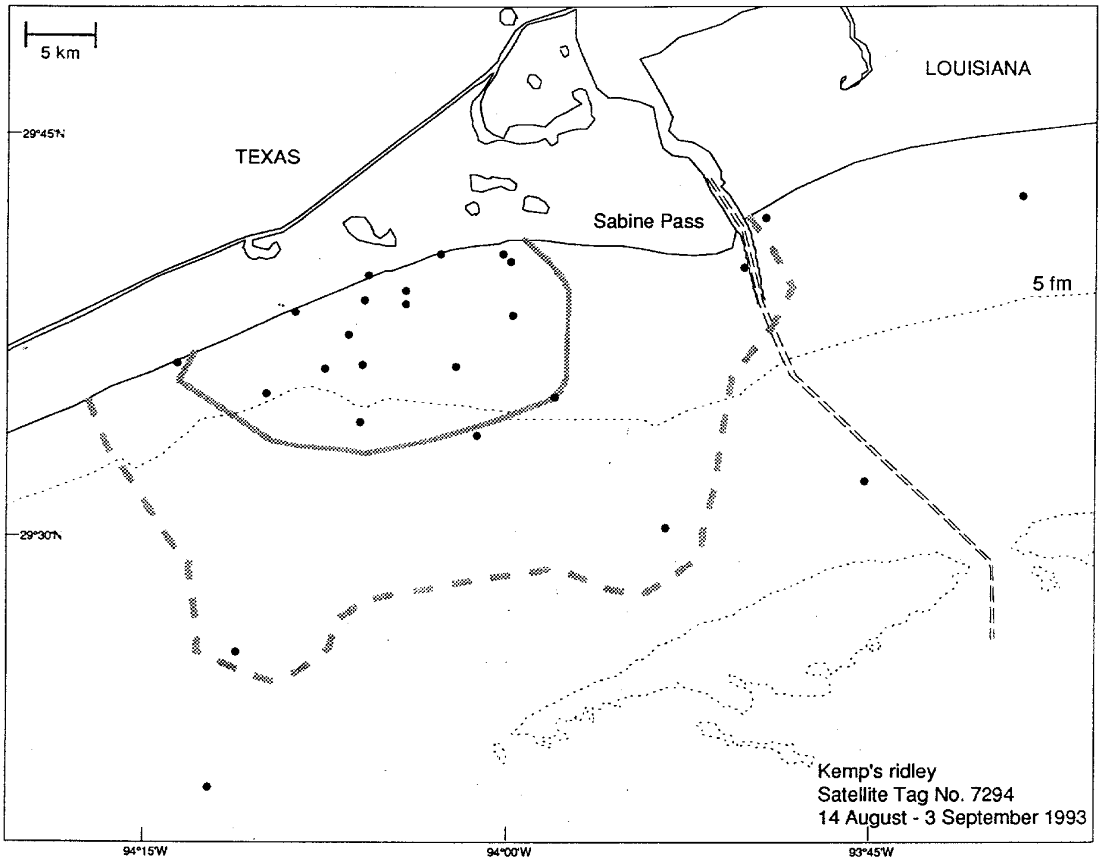


Figure 4. Range (95% utilization distribution) and core area (56% utilization distribution) for S7294. Range is outlined with a dotted line and core area is outlined with a solid line.

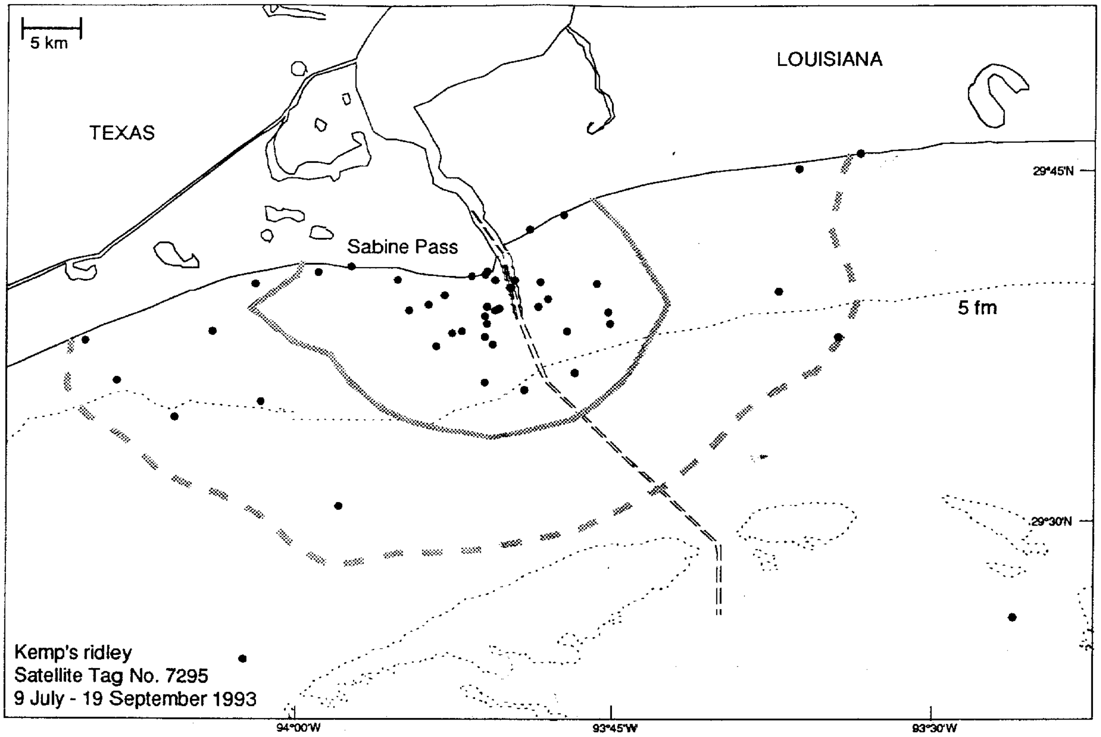


Figure 5a. Range (95% utilization distribution) and core area (56% utilization distribution) for S7295. Range is outlined with a dotted line and core area is outlined with a solid line.

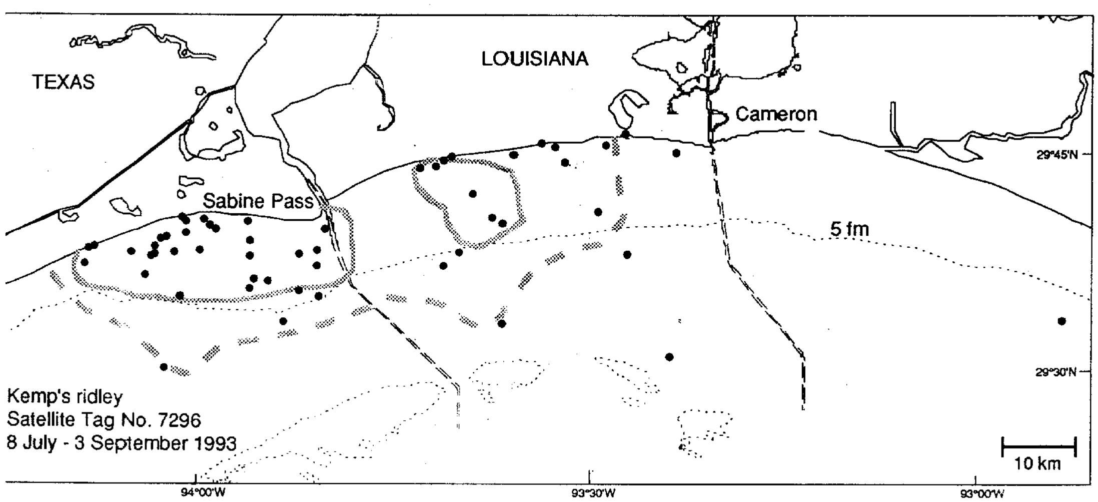


Figure 5b. Range (95% utilization distribution) and core area (53% utilization distribution) for S7296. Range is outlined with a dotted line and core area is outlined with a solid line.

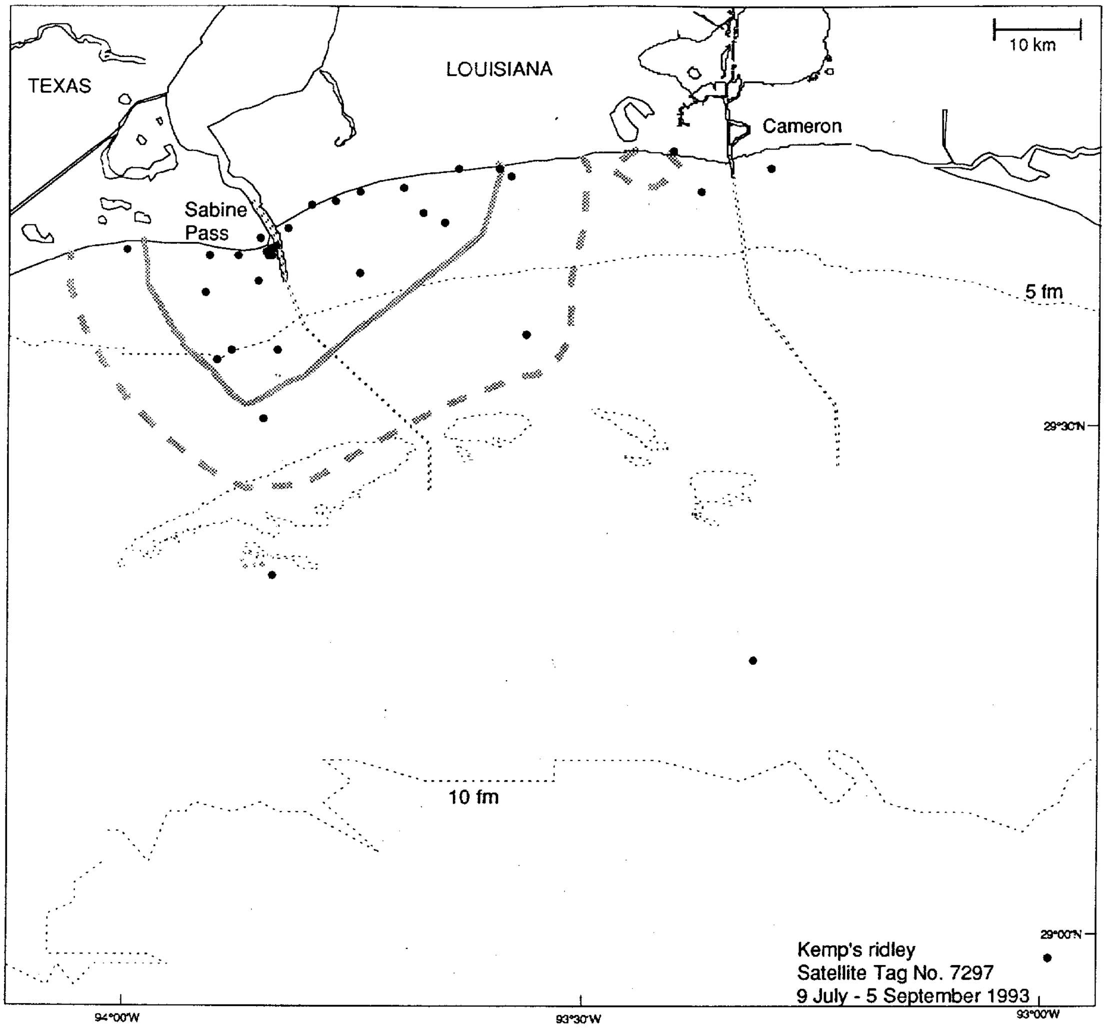


Figure 6. Range (95% utilization distribution) and core area (63% utilization distribution) for S7297 Range is outlined with a dotted line and core area is outlined with a solid line.

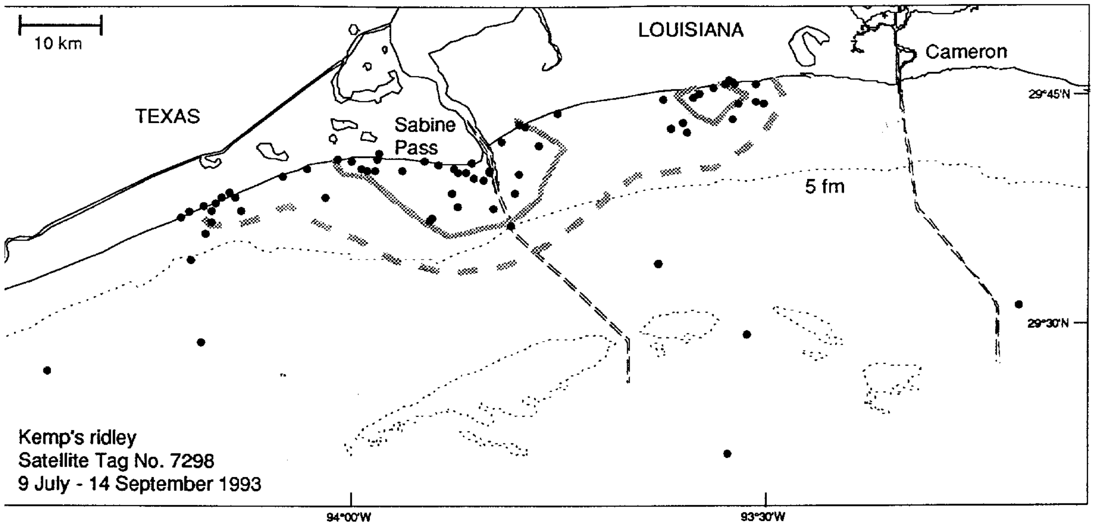


Figure 7a. Range (95% utilization distribution) and core area (51% utilization distribution) for S7298. Range is outlined with a dotted line and core area is outlined with a solid line.

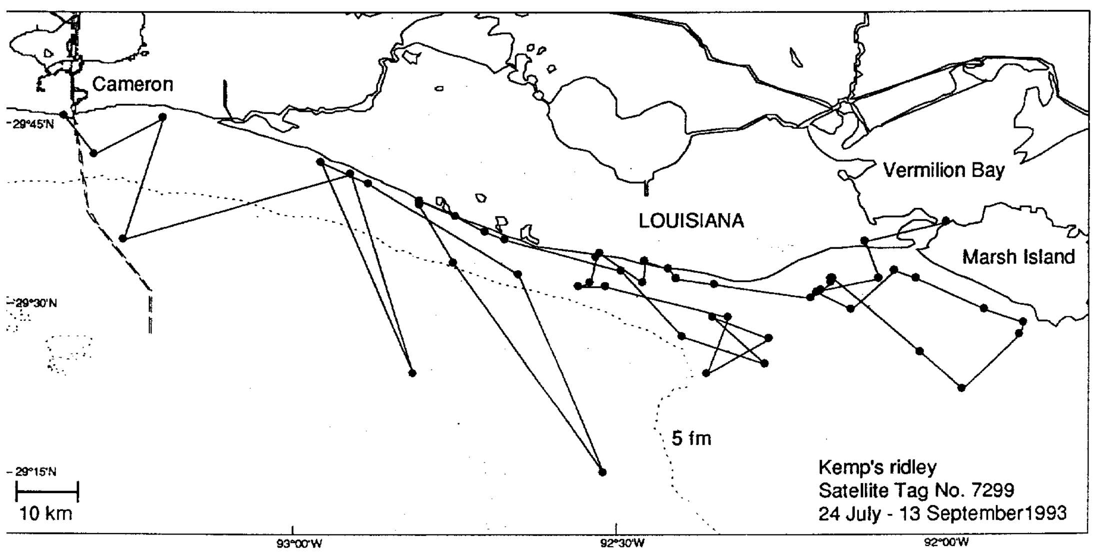


Figure 7b. Movement of S7299. Range and core area could not be determined for this turtle because of a directed easterly movement.

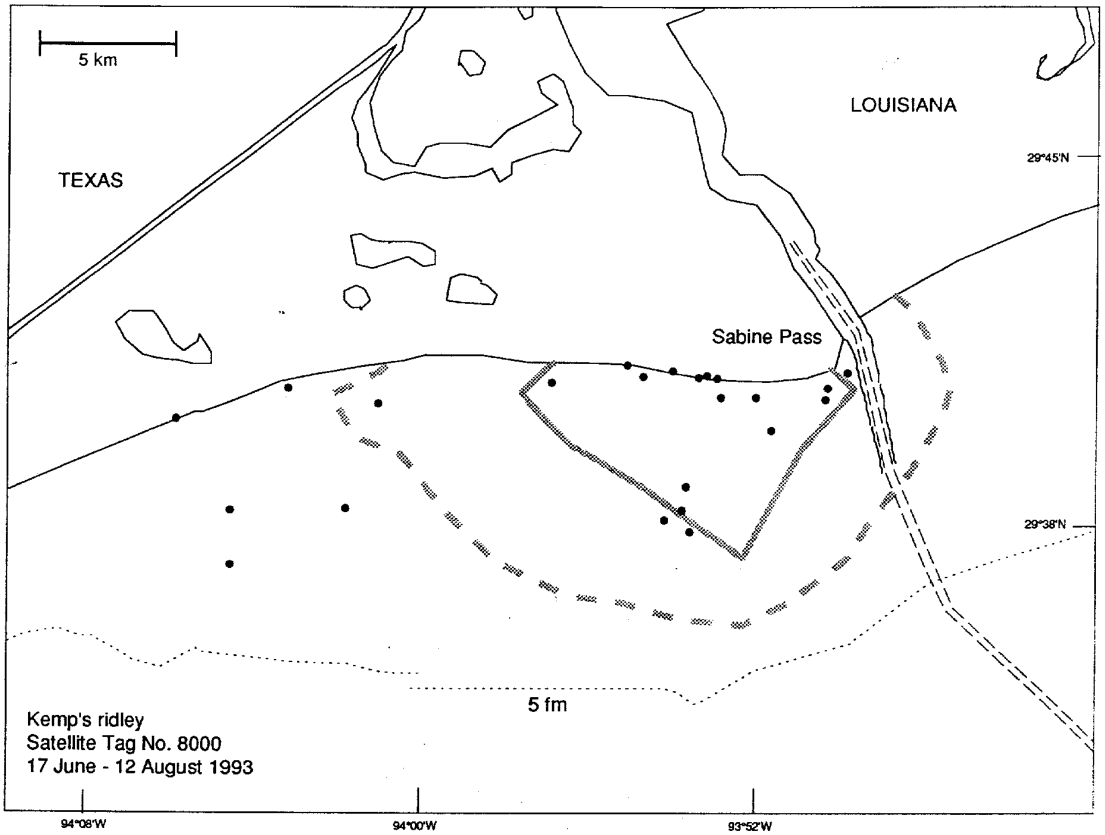


Figure 8. Range (95% utilization distribution) and core area (57% utilization distribution) for S8000. Range is outlined with a dotted line and core area is outlined with a solid line.

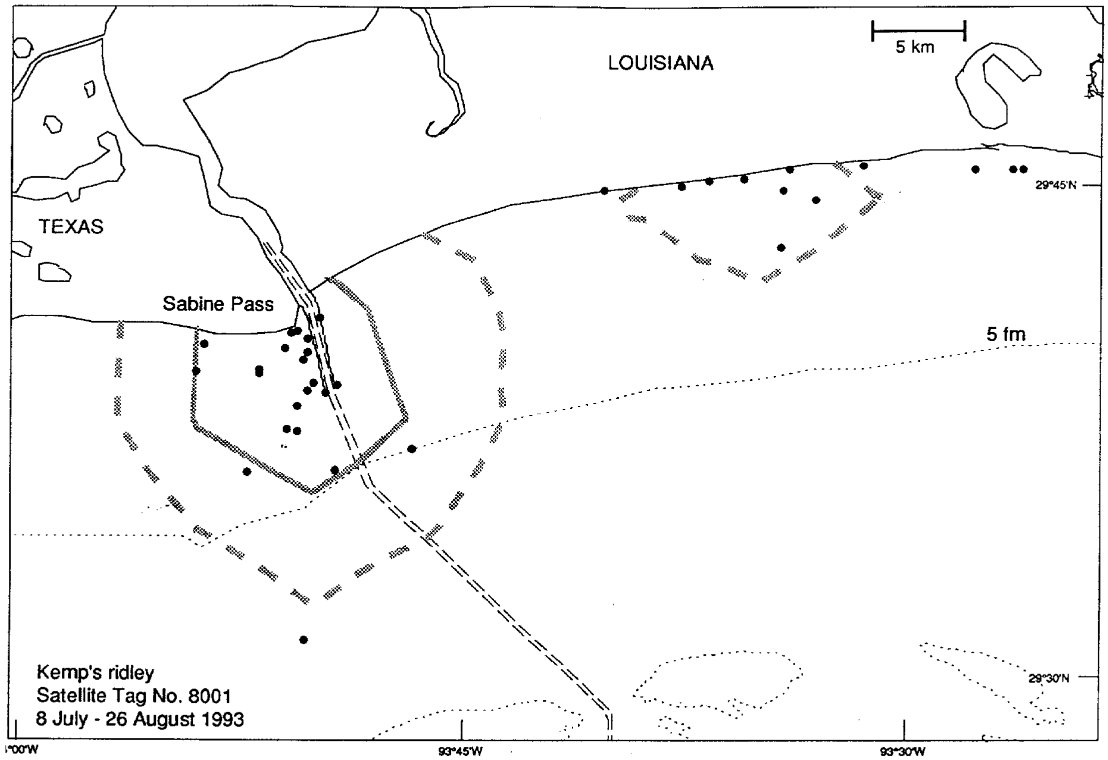


Figure 9a. Range (95% utilization distribution) and core area (61% utilization distribution) for S8001. Range is outlined with a dotted line and core area is outlined with a solid line.

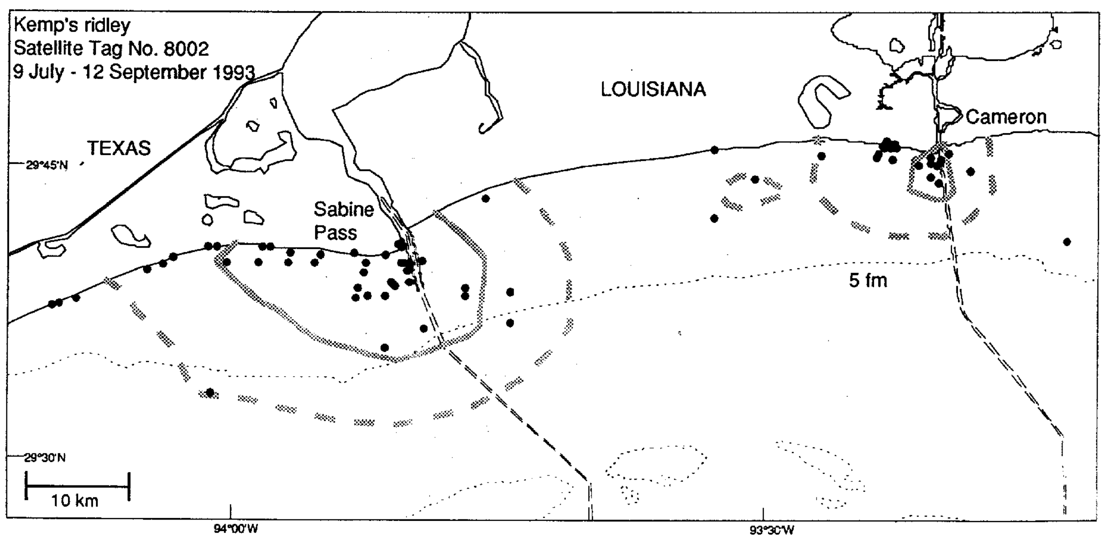


Figure 9b. Range (95% utilization distribution) and core area (57% utilization distribution) for S8002. Range is outlined with a dotted line and core area is outlined with a solid line.

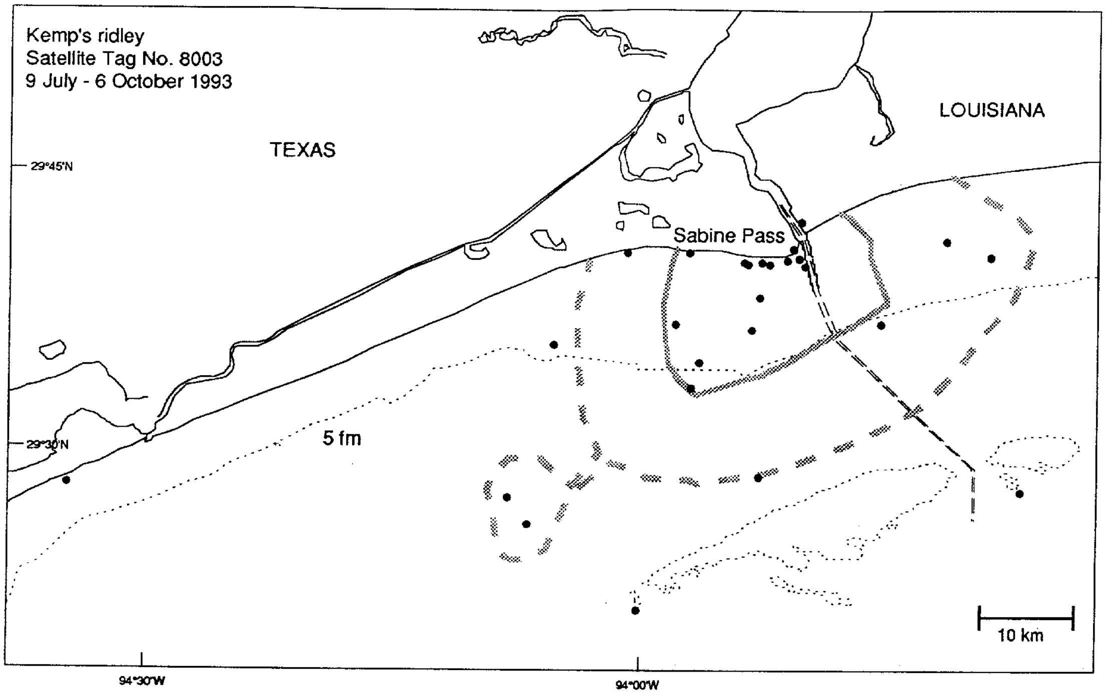


Figure 10a. Range (95% utilization distribution) and core area (56% utilization distribution) for S8003. Range is outlined with a dotted line and core area is outlined with a solid line.

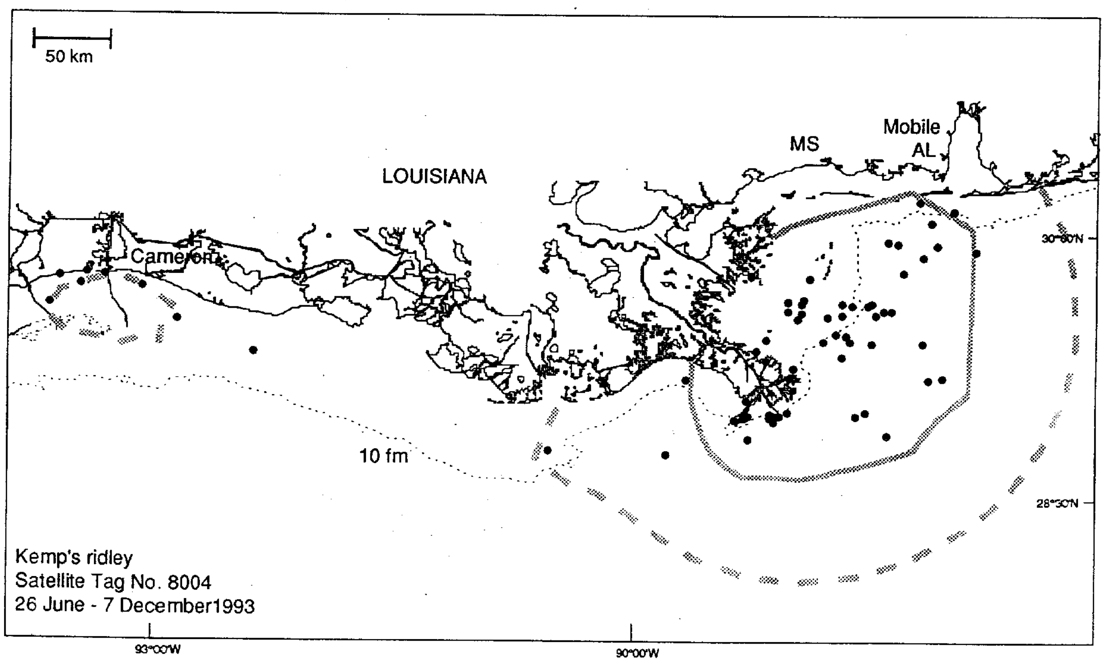


Figure 10b. Range (95% utilization distribution) and core area (67% utilization distribution) for S8004. Range is outlined with a dotted line and core area is outlined with a solid line.

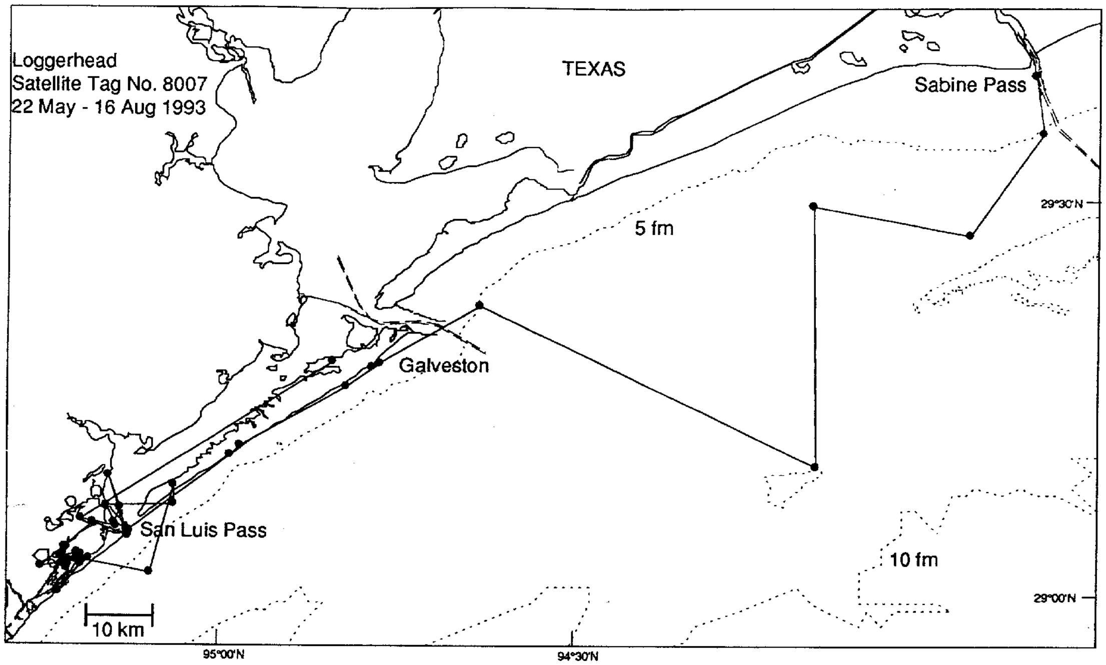


Figure 11a. Movement of S8007. Range and core area could not be determined for this turtle because of an westerly directed movemnt.

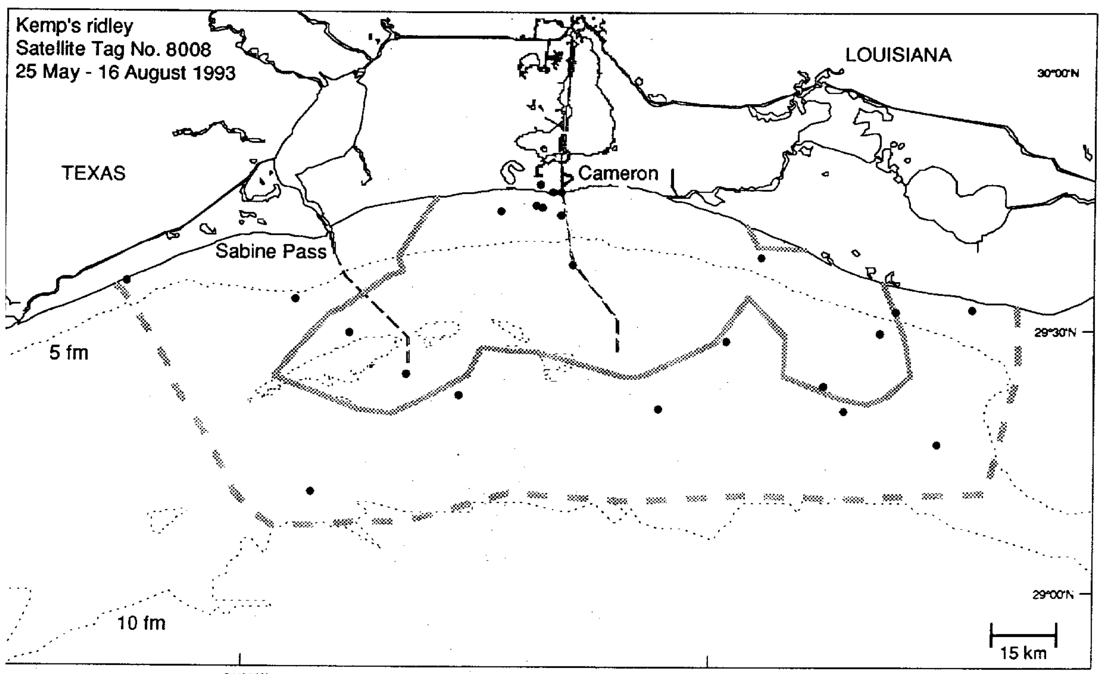


Figure 11b. Range (95% utilization distribution) and core area (50% utilization distribution) for S8008. Range is outlined with a dotted line and core area is outlined with a solid line.

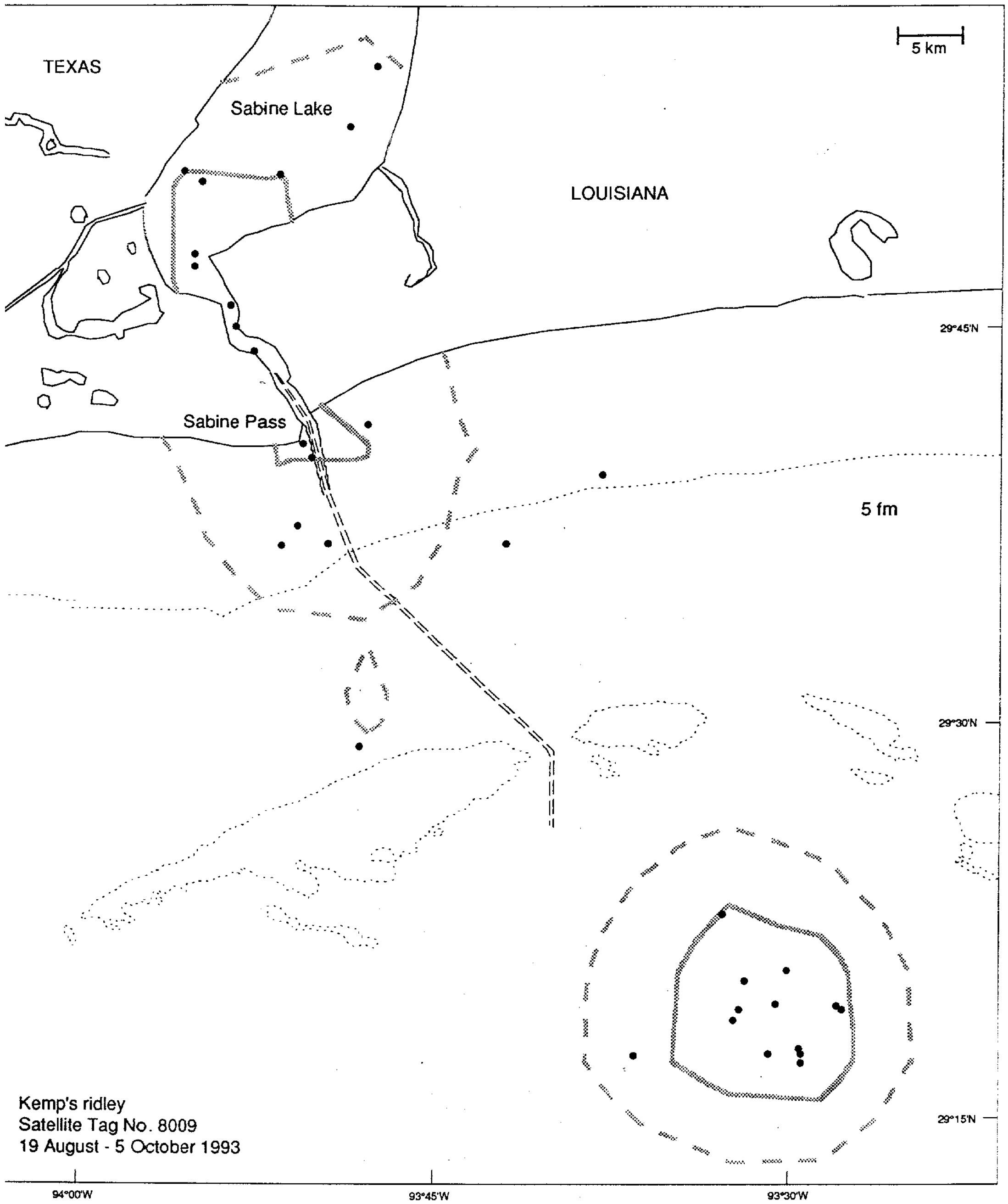


Figure 12. Range (95% utilization distribution) and core area (50% utilization distribution) for S8009. Range is outlined with a dotted line and core area is outlined with a solid line.

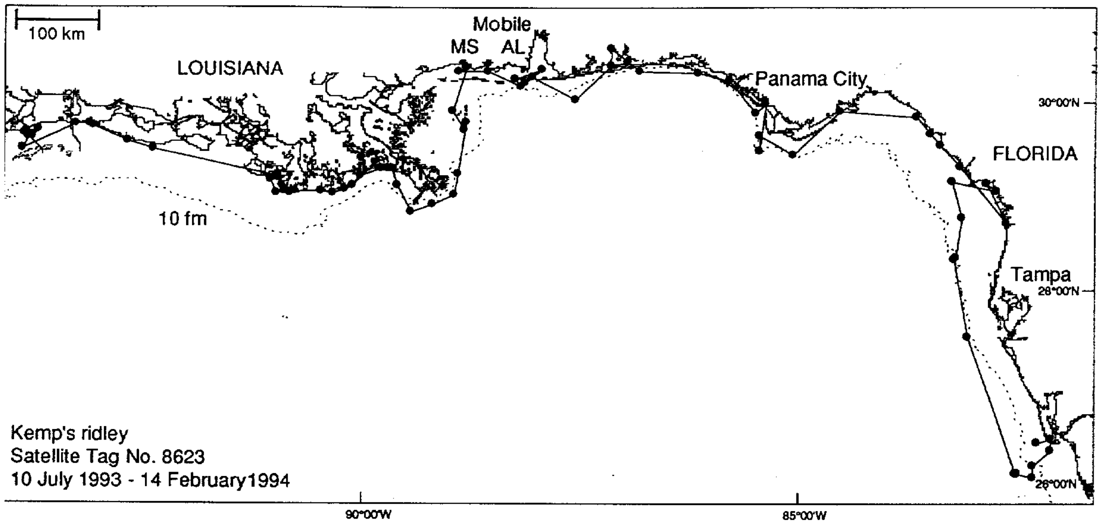


Figure 13. Movement of S8623. Range and core area could not be determined for this turtle because of an easterly directed movement.

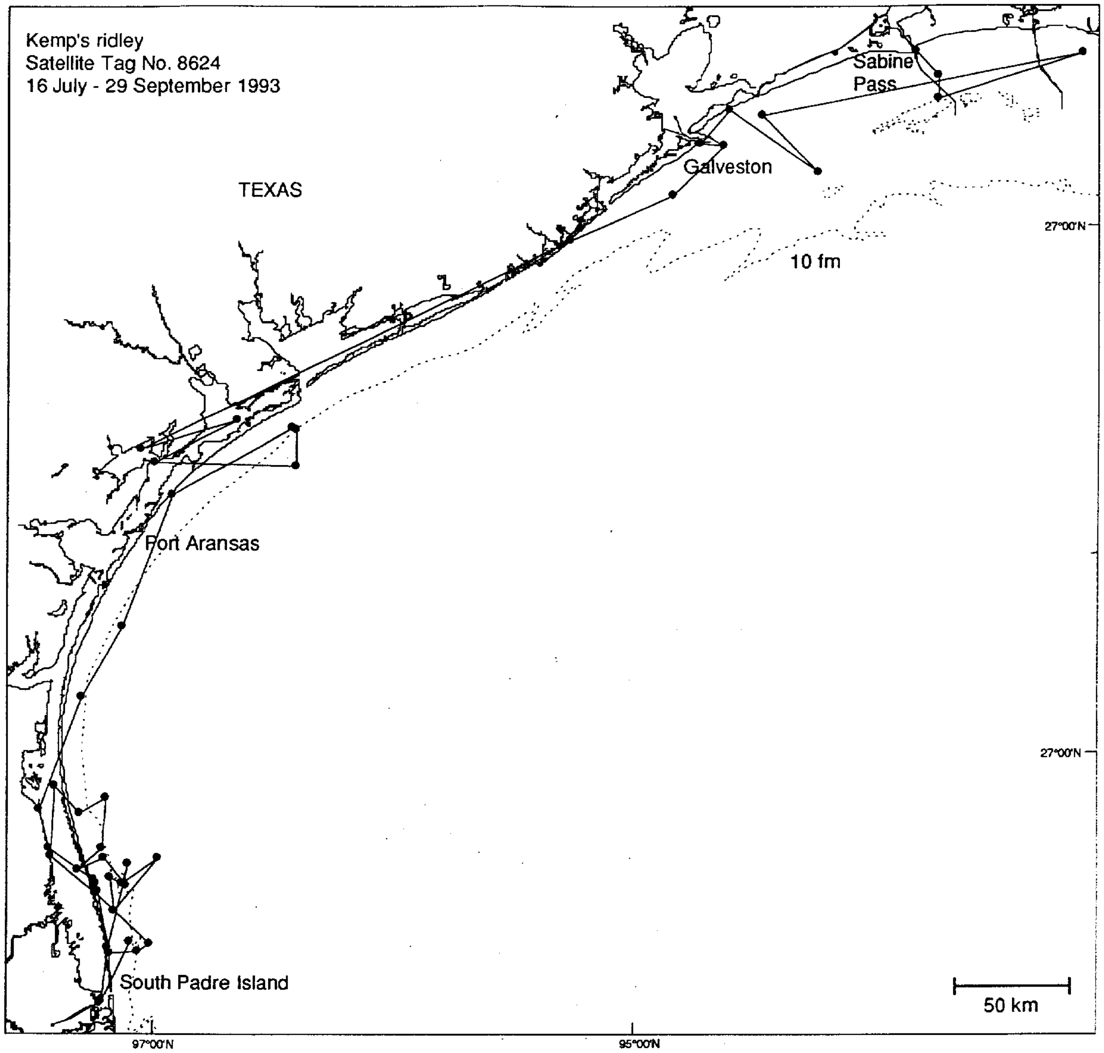


Figure 14. Movement of S8624. Range and core area could not be determined for this turtle because of an westerly directed movement.